Electrical Engineering

THE

JOURNAL of the A. I. E. E.

Volume 50 JANUARY, 1931 Number 1

Published Monthly by the

AMERICAN INSTITUTE
of
ELECTRICAL ENGINEERS

33 West 39th Street, New York

Copyright 1931

WILLIAM S. LEE, *President*
F. L. HUTCHINSON, *National Secretary*

PUBLICATION COMMITTEE
W. S. GORSUCH, *Chairman*
H. P. CHARLESWORTH A. E. KNOWLTON
F. L. HUTCHINSON E. B. MEYER

PUBLICATION STAFF
GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

Entered as second class matter at the N. Y. Post Office, May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

Permission is given to reprint any Institute article or paper provided full credit is given.

The Institute is not responsible for any statements made or opinions expressed in its publications.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America.

Front Cover—

The ever-alluring night-time skyline of New York City; Manhattan as it appears from Governors Island.
—Photo by Underwood & Underwood

Automobiles vs. Railways for Urban Transportation 4
By CHARLES GORDON, *American Elec. Ry. Association*

Industry vs. Technical Education 8
Reflections from Lehigh University Educational-Industrial Conference

Australasia as Seen by an Engineer 12
By PAUL M. LINCOLN, *Cornell University*

Automatic Operator Improves Efficiency 14
By S. LOGAN KERR, *I. P. Morris & DeLaVergne, Inc.*

Electricity in the Cement Industry 18
By R. H. ROGERS, *General Electric Company*

What of the Foreign Job? 21
By PERCY H. THOMAS, *Consulting Engineer*

Small Alternators Now Fully Automatic 23
By EARLE R. WETZEL, *Kohler Company*

Insulation Research Turns Again to Fundamentals 24
- **Year's Efforts Show Commendable Progress** . . 24
  By DR. J. B. WHITEHEAD
- **Conductivity of Insulating Oils** 26
- **Impregnated Paper Insulation** 27
- **Predetermination of Cable Deterioration** . . 28
- **Chemical Research in the Field of Dielectrics** . 28

—Turn to Next Page—

Relays to Operate in 1/60th Second 29

Tennessee Lightning Investigation Continues . . 30
By J. E. HOUSLEY, *Knoxville Power Company*

Lighting Airway Beacons 31
By F. W. CARTLAND, *Westinghouse Elec. & Mfg. Company*

Vacuum Tubes Lead the Way 34

Federal Regulation of Water Power 35
By FRANK E. BONNER, *Federal Power Commission*

Governor Performance During System Disturbances 37
By R. C. BUELL, R. J. CAUGHEY, E. M. HUNTER, *General Electric Company,* AND V. M. MARQUIS, *American Gas & Electric Company*

Lightning Arresters for 268.4-Kv. Service . . . 41

Noise Measurements 42
By JOHN C. STEINBERG, *Bell Telephone Laboratories*

Private-Wire Telegraph Service 45
By R. E. PIERCE, *American Tel. & Tel. Company*

Ninety Miles an Hour in a Trolley Car! 49

News of Institute and Related Affairs ◆ ◆ ◆ ◆ **50**

Engineering Index (Current Literature) . . 64
New Books 68
Local Institute Meetings 69
Employment Notes 77
Membership 79
Personnel 81
Industrial Notes 88

WINTER CONVENTION program presents a wealth of technical papers of timely importance, and offers opportunities for intensely interesting inspection trips. (See page 50)

◆

NATIONAL OFFICERS for 1931 were nominated Dec. 5, 1930, by the national nominating committee, meeting at Institute headquarters, New York. Fifteen delegates were present, representing every geographic district. (See page 53)

◆

ENGINEERING INDEX review service covering 1,800 current technical periodicals is inaugurated in this issue with a listing of electrical engineering references. (See page 64)

◆

LICENSING OF ENGINEERS is one of the subjects to be studied by a recently enlarged professional committee headed by H. A. Kidder. (See page 53)

◆

CHARLES GORDON, executive secretary of the American Electric Railway Association and thoughtful student of urban transportation problems boldly recommends less attention to new streets for automobiles and decidedly more attention to more tracks for better street cars. (See page 4)

◆

EDUCATORS AND INDUSTRIALISTS, in a two-day session at Lehigh University, revealed differing viewpoints as to what constitutes a suitable technical education. Much information of value to technical students came out of the discussions. (See page 8)

◆

DR. JOHN B. WHITEHEAD, energetic leader in the field of insulation research and dean of the Johns Hopkins University engineering school, is making noteworthy progress in his efforts to find common ground for the proponents of conflicting theories. (See page 24)

◆

AIRWAY BEACONS in out-of-the-way places now may be lighted directly from high-tension transmission lines according to F. W. Cartland of the Westinghouse company who describes equipment and methods. (See page 31)

◆

FRANK E. Bonner, executive secretary of the Federal Power Commission, outlined the major functions of the commission in speaking before the recent annual meeting of the American Society of Mechanical Engineers. (See page 35)

"Electrical Engineering"

EVEN before you opened this issue of the monthly publication of the Institute you noticed a change. As you proceed through the pages you may sense more departures from the "Journal" of the last few years.

ALL this is part of an evolutionary scheme to enlarge the value of the Institute to every member regardless of age, location, responsibility, interest in the field of electrical engineering or in its professional significance. To bring the engineer to the Institute obviously is too costly in time and money; therefore, every effort is being made to bring the Institute to its members. Toward this end some years ago Sections were instituted and more recently District meetings were promoted to decentralize activities and render the national atmosphere frequently accessible to members everywhere. Now, as a next step, the monthly publication revises its format, and essays to interpret the latest technical developments and other matters of professional interest more in accord with the broad requirements of the whole membership.

IF these changes arouse in you a happy appreciation you surely will want to impart it to some hesitating applicant. Or, you could help the editor by telling him. In fact, why not tell him anyhow? This is your Journal and you have that privilege and duty.

President.

THIS, the first issue of ELECTRICAL ENGINEERING, marks another important step in the development of the American Institute of Electrical Engineers. Under this new and more appropriate title, the successor of the Journal of the A. I. E. E. will be published monthly as the official organ of the Institute, but with a much broader scope.

THE survey made during the past two years by the Publication Committee, under the able chairmanship of Mr. W. S. Gorsuch, clearly indicated a very general demand that the Institute continue to publish a high-grade electrical engineering periodical including, however, not only engineering and scientific papers and discussions presented at the various Institute meetings, but also much additional matter reflecting current progress in the art of electrical engineering.

ORIGINAL papers on theoretical or experimental investigations, important inventions, discoveries and developments in the fields of electrical engineering and the related sciences, will continue to constitute the major portion of the contents. The high standard that always has been maintained in the Institute's publications will be continued. Based upon the constructive work of the past, the broadened scope of the publication is a logical step in the evolution of the Institute, the purpose being to supply information that will enable the individual engineer to keep more fully informed of recent developments in the theory and practise of all branches of electrical engineering.

ELECTRICAL ENGINEERING will reflect the steadily increasing part that the applications of electricity are taking in our modern civilization. More attention will be given to the effects of engineering upon human relationships; in particular, the influence of electrical engineering in the fields of sociology, economics, and other social sciences.

THE ability of the leaders in the engineering profession, for effective collective effort, has been developed to a large extent by their activities in the Institute and in similar organizations. ELECTRICAL ENGINEERING is one of the instruments established by the Institute for the exchange of ideas, and it affords the individual engineer opportunity to contribute items of interest and value from his experience for publication in exchange for the ideas which he receives from other contributors.

THEREFORE, the Publication Committee and the editorial staff will be glad to consider contributions similar in scope to those published in this issue, in which a beginning has been made in the direction indicated. It is expected that the future issues will constitute, even more fully than the monthly "Journal" has in the past, an authoritative history of developments in the electrical engineering art and the related sciences, which together constitute the basis for evolution in the electrical industry.

F. L. Hutchinson

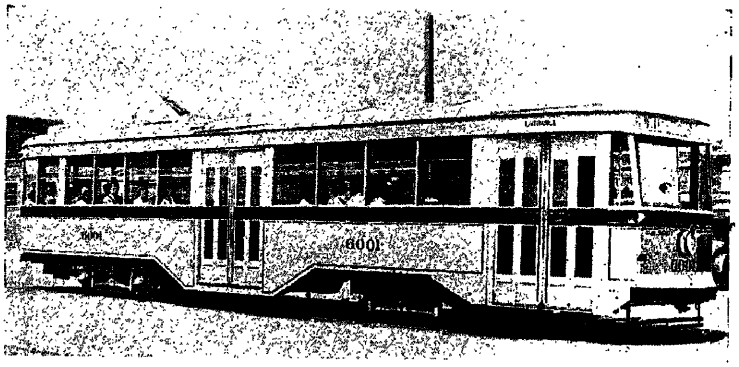
National Secretary.

Automobiles vs. Railways for Urban Transportation

Electric power in urban transportation presents an opportunity and a challenge to the electrical engineer that is emphasized more strongly as street congestion grows worse in all centers of population. Tremendous public expenditures are being made for street improvement, but will that afford economical transportation?

By Charles Gordon

Managing Director,
American Electric Railway Association



A 1930 model street car. Designed for comfort and high speed, it is a most efficient user of street space

FUNDAMENTAL to all industrial progress lies progress in transportation. Only as man has succeeded in overcoming the limitations of distance and time has he moved forward in mastering his environment. When man learned how to substitute energy derived from wood and coal for that of beasts and of his own body, the first extended commercial applications of the new power were made to transportation. Since then, the development of each new form of power has resulted largely from the dominating importance of the need for transportation improvement. It is quite natural, therefore, that the fiercest battles for achievement and for survival of the fittest among the vanguard of mechanical, electrical and automotive engineers are still being waged in the field of transportation.

Man first applied the magic of steam to make the railroad and the steamship. With them he took his first great step in the mastery of distance and time. Improved transportation permitted rapid growth of industrial and commercial centers which were required when steam-driven machinery in turn replaced handcraft. In consequence of these two developments, civilization experienced an industrial revolution.

Steam power has enhanced the economic importance of cities. Increasing numbers of people were drawn by economic forces to rapidly growing industrial and commercial centers. Therein was born a new need—the need for improved local transportation within these urban areas. For a time animal power was sufficient for the purpose, but as population and the areas of cities grew there was need for something more efficient than animal power; and without the smoke and other limitations of steam. That need stimulated the development of electric motive power and its first major application. Local transportation in cities offered early electrical men a most important commercial opportunity; it stimulated the development of generating, motor, and control equipment. Subsequently, as had occurred with steam, transportation shared with other uses its position as the major field for application of the new power.

It seems particularly significant to electrical engineers today, as an indication of the rate at which we are moving, that the history of electric power is encompassed within the lifetimes of two men whose names stand out in its early development. Sprague, who built what is counted the first commercially successful electric railway line, and Edison, who after conducting early experiments in lighting and transportation concentrated upon applying electricity to light the world, have both been permitted by kind Providence to live to see the marvelous achievements of their early struggles.

In the transportation field, for people who were content to travel collectively, steam and electricity reigned supreme. But the horse has survived and has continued for many years to serve those who required individual transportation or desire exclusiveness. The industrial age opened as a utilitarian age. Transportation men concentrated upon utility and efficiency, when the horseless carriage first appeared upon city streets they gave it barely passing attention. They failed to recognize its significance as marking the introduction of a new form of power—the internal combustion engine—applied to individual transportation. But within three decades, the automotive vehicle has so stimulated the desire for individual convenience, speed, and luxury in travel that it congests the streets of our cities and spreads out over the land on a gigantic system of highways built by the public to make its use possible.

An address delivered at the A. I. E. E. Southern District Meeting, Louisville, Ky., Nov. 19, 1930, under the title "Electric Power in Urban Transportation."

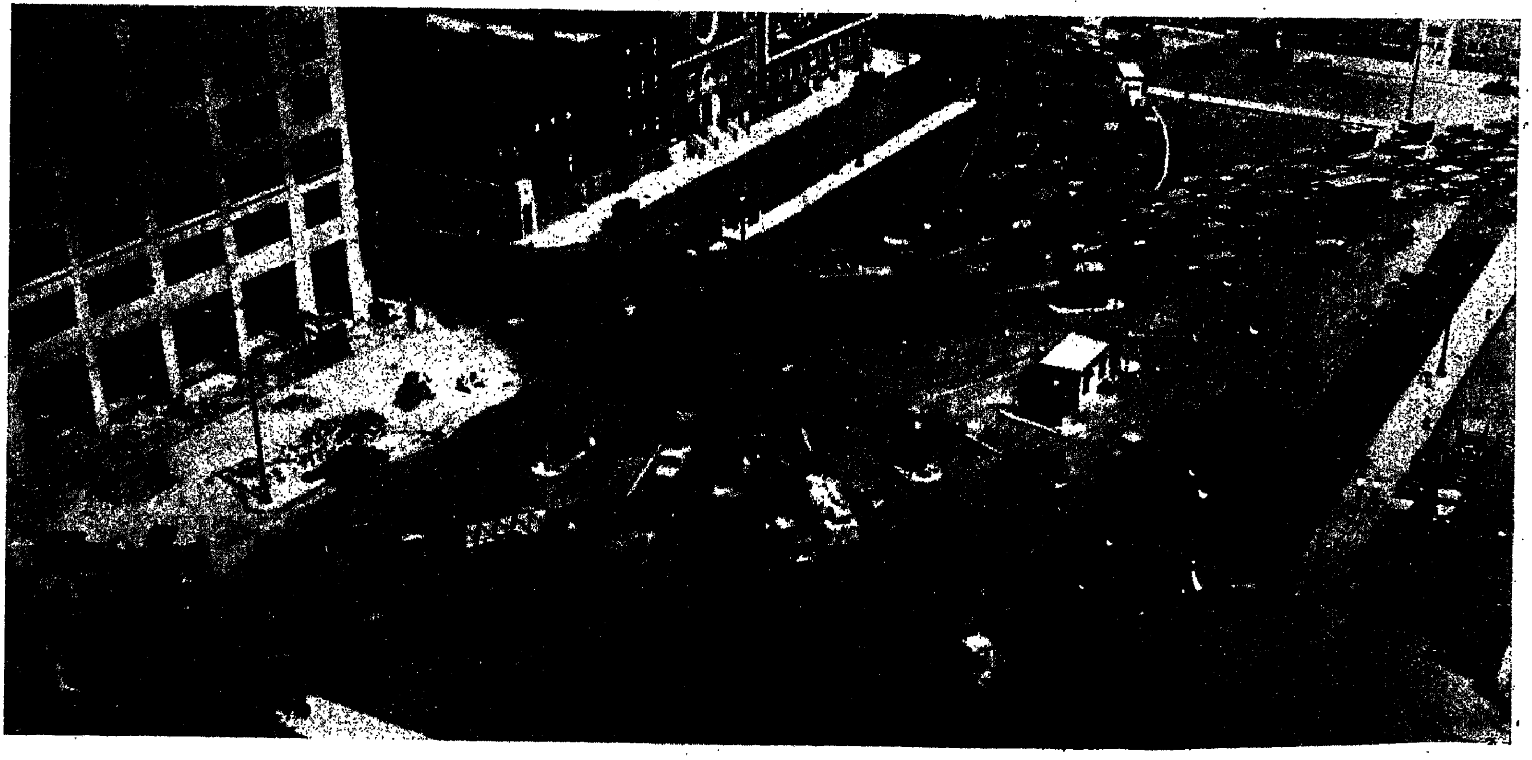
Again, the introduction of a new form of power made for new standards of transportation. Again, far-reaching social and economic changes result. Starting with the individual vehicle, the automotive engineer has cut the ties that bound man to earth and now carries him through the air. And while he pushes rapidly forward these achievements he also challenges the mechanical and electrical engineer in a field of collective travel. He has plunged into the transportation power battle both within and between cities, and contests at many points the reign of steam and electric power, on land and on sea.

So spectacular and rapid has been the progress made by automotive power that laymen and many engineers as well are inclined to write off electric transportation in cities along with the horse-car. And although they do not go quite so far as to relegate the railroad to the limbo of the stage coach, there is a strong tendency to assume that the internal combustion engine on the highway will rapidly decrease the field of usefulness of the steam engine on rails. In the early stages of railroad electrification there was a similar tendency in the minds of enthusiasts to consign the steam locomotive to the scrap heap; nevertheless, locomotive designers met the advance of electric power and have given way to it only in high-density terminal areas and under the special conditions presented by steep mountain grades. With these exceptions the steam locomotive continues to dominate long haul transportation.

It seems particularly timely, therefore, that electrical engineers examine a little more closely the problem of transportation in urban areas where the great electrical industry had its origin barely fifty years ago; and where, in turn, predictions are freely made that electric power will be replaced by the internal combustion engine. In this examination we shall need to concern ourselves as much with economics as with engineering, for it is on the scale of economics that the achievement of the engineer must be weighed and finally judged.

Before proceeding, one additional thought seems worthy of mention here; just as the automotive engineer took to the air to make further conquests of space and time in transportation, so did the electrical engineer make new conquests through the air in the field of communications. In these respective fields each reigns supreme and each one records almost daily, achievements which whet our imaginations in an effort to foresee man's next step to master his environment. It is not surprising, therefore, that the eyes and the minds of electrical engineers, as well as of the public at large, have been diverted from the relatively unspectacular field of urban transportation which gave electric power its early impetus.

Though not so spectacular and therefore less in the public eye, transportation facilities within urban areas lie at the very heart of our modern economic system, for these are points of concentration for our vast industrial and commercial machinery. Without adequate and efficient elevators the modern skyscraper would be impossible. Without an adequate circulatory system, the whole urban area in which the skyscraper and the factory, the apartment building and the department store are merely units, would cease to function; for the economic existence of these areas is dependent upon the travel facilities by which people may move conveniently between home and office, factory and store. In large measure, the economic height of the skyscraper is



Typical scene at the New York entrance to the Holland Tunnel under the Hudson River. A single track of street cars operating with seated loads would more than double the passenger capacity determined on one hand by land values, and on the other, by problems involved in providing vertical transportation. So also physical arrangement of cities as a whole, and the economic location and character of property development, are determined by land values and the facilities for horizontal transportation.

In every large city the demand for street space far exceeds the supply; in congested areas it is obviously impossible for all who would do so to move by individual vehicle. How then shall the need be met? Will it be by the construction of two, three, four or even more, levels of streets as some suggest? And if so, will these be for gasoline-propelled vehicles operating on pavements, or for electrically-propelled vehicles operating on rails?

There is little question as to the public's preference at the present time. While the electrical engineer has been concentrating upon utility and efficiency with little regard for mental and esthetic values, the automotive engineer has been directing his attention to speed, attractiveness, and even luxury in the design vehicles. The result was natural and inevitable; it verified an ages-old principle that the price which mankind is willing to pay to achieve a desire is measured by the intensity of the desire and his ability to make whatever sacrifice is necessary to achieve it. The automotive engineer sensed the importance of the desire for speed, comfort and luxury in travel, and concentrated upon meeting it. As a result the public likes and wants the automobile and will not be deterred by cost alone from providing facilities for its use.

Efficient local transportation is vital to the modern economic system. This loading terminal expedites traffic at a Detroit industrial plant

The prediction then that we shall build our cities of the future for automotive travel regardless of cost is sound in so far as it assumes that cost is secondary to popular desire. But in the light of facts it assumes that there is no limit to the price which the public is willing or able to pay to ride by automobile. It is not so much the cost to the individual to which attention should be directed—high as that may be—but the relative costs to the community, of travel by electrically propelled transit facilities and individual automobiles.

By considering the relative passenger capacity of roadways for individual vehicles as compared with the capacity of collective transportation facilities the magnitude of this problem may be grasped readily. Under extraordinary conditions, the maximum practicable capacity of a single lane of motor vehicles is approximately 1,800 vehicles per hour; this on the assumption of uninterrupted flow of passenger automobiles only, free from interference by cross traffic. For calculating traffic capacity of a street *free of all crossing interference*, the figure is high rather than low, and would represent a condition of congestion which would be neither convenient nor satisfactory to the operators of vehicles. For example, the maximum recorded traffic flow through the Holland Tunnel under the Hudson River between Jersey City and New York City occurring on May 30, 1930 was 1,253 vehicles per single lane. The ultimate capacity of the tunnel in two lanes is computed as 1,270 automobiles per lane per hour. For calculating highway capacities, let us use the figure of 1,500 vehicles per lane per hour *for a highway with no grade crossings*, which would represent the practical maximum at satisfactory speeds. Likewise, careful analysis of traffic checks taken under a wide variety of conditions indicates that approximately 900 vehicles per single lane per hour is a fair average for calculating the maximum practicable capacity of a single lane on a major arterial street or highway *subject to normal interruption of cross traffic.*

The above capacities apply only to a single lane; but roadways are not ordinarily single lanes, but consist of several lanes on which traffic weaves from lane to lane, reducing the capacity per lane as the width of the street increases. Though the exact effect of this factor of weaving upon multiple-lane highway capacity cannot be accurately measured, it can be fairly approximated and the figures below give the results to be expected under average conditions:

RELATIVE CAPACITY OF MULTI-LANE STREETS IN COMPARISON WITH SINGLE-LANE

Number of lanes in one direction	Efficiency per lane in per cent of single lane
1	100
2	89
3	79
4	70
5	62

The capacity of roadways of various widths is, therefore, readily determinable, calculation being possible under three conditions: First, express movement on a roadway with no grade crossings and no stopping; second, on a roadway such as a city boulevard subject to grade-crossing interference, but with parking prohibited; and third, a roadway with normal grade-crossing interference and with the further reduction

MAXIMUM PRACTICAL CAPACITY PER HOUR OF ROADWAYS UNDER TYPICAL CONDITIONS

	No Grade Crossings—No Stopping Permitted		City Boulevard with Grade Crossings—Parking Prohibited		City Street with Grade Crossings—Parking Permitted	
Roadway Width in one Direction	Number of Moving Lanes	Vehicles per Hour	Number of Moving Lanes	Vehicles per Hour	Number of Moving Lanes	Vehicles per Hour
20 ft.	2	2,650 (a)	2	1,200	1	750
30 ft.	3	3,550	3	1,800	2	1,450
40 ft.	4	4,200	4	2,200	3	2,000

(a) New Jersey State Highway Department estimates 2,400 cars per hour under similar conditions on the elevated express highway of Route No. 25.

in capacity from stopping and parking along the curb. These capacities are shown above.

In the last two columns of the foregoing tabulation parking necessarily eliminates completely the use of one lane; it also, due to the interference of vehicles moving to and from the curb, reduces the capacity of the lane nearest the parked lane. Under the conditions of capacity volume and one-hour parking regulations, it is safe to estimate that cars moving to and from the curb will reduce by at least 20 per cent the normal capacity of the lane next adjacent.

We are now in position to measure the *passenger* capacity of these typical roadways; observations made in a number of cities indicate that use of automobiles in city travel result in an average loading per vehicle of approximately 1.7 passengers. Consequently, in calculating the travel capacity of roadways in cities for individual vehicles it is safe to assume that the loading per vehicle will vary little from that indicated by these observations which represent averages over a considerable period in many locations.

For purposes of comparison, the capacities of electrically-propelled travel facilities in cities are readily determinable. A single track on an ordinary major city street—assuming conventional street cars, approximately 48 ft. long seating 60 passengers—has a maximum capacity of about 180 cars per hour. Through congested areas in some cities a number greater than this is actually being moved over a single track, but to insure satisfactory speed a maximum capacity of 150 cars per hour will be assumed. Thus, a single track on the surface of a conventional street will move 9,000 *seated passengers per hour*—considerably more than the number of people traveling in automobiles on a *grade-separated, elevated highway* with four express lanes in one direction. Putting this in another way, the passenger capacity of a single track of conventional street cars, carrying only a *seated* load and running on a main business street subject to cross traffic interference, is more than twice the observed maximum through the present Holland Tunnel under the Hudson.

Furthermore, if two such tracks are located in the center of an ordinary 60-ft. roadway with parking prohibited, approximately 1,000 automobiles per hour may move through this street in each direction, thus making the capacity of such an ordinary 60-ft. city street, subject to cross traffic interference and with street cars carrying only a seated load, two and one-half times the passenger capacity of the Holland Tunnel. If we remove the street cars and turn over such a 60-ft. roadway exclusively to automobiles, continuing to exclude parking, it will require *in addition to the old street,* two and one-half new boulevards of the same width to move the same number of people.

In these comparisons, bear in mind that street cars are assumed to carry *seated loads only,* and highway lanes are assumed to carry the maximum number of automobiles that can move at approximately satisfactory speed.

The future use of electrically-propelled public transportation facilities in cities will be determined by the extent to which they can approximate automobile standards of comfort while retaining the substantial advantage of great economy in space requirements. It has therefore been assumed that in comparing the space requirements of an adequately developed public transportation system with a highway system for automobiles every passenger is an ideal standard of comfort.

When the growth of a city and consequent density of travel requires the construction of additional facilities above or below the present street surface, the community has the alternative of designing these facilities for collective travel in electrically-propelled vehicles on rails, or for individual travel in automobiles. It is important therefore to examine the relative carrying capacity of these two alternative forms of construction: Here, the community is called upon to provide new facilities for its circulatory system; under given conditions of travel density the number of new grade-separated arteries required, whether overhead or underground, will be determined by their passenger carrying capacity, established in turn by the decision as to whether they are to be equipped with roadways for automotive vehicles or with rails for electrically-propelled cars or trains.

One four-track subway, of 56-ft. excavated width and carrying two express and two local tracks like the New York subways has an ultimate capacity of 35 ten-car express trains per hour on a single express track and requires 30 six-car local trains on the adjoining track for intermediate station transfer travel. Assuming only a seated load per express train and corresponding conditions in local trains, such a four-track system will readily move approximately 47,000 people per hour in each direction. To permit these people to move by automobile, assuming that they could afford to do so, the community would have to provide approximately 10 elevated or underground highways of corresponding width. Here again, the capacity of electric trains is calculated on *a seated basis only.* It would require at least 20 tunnels or elevated highways of equal width to carry in automobiles the people actually transported at present standards of loading on one four-track line of subway in New York.

To solve the growing problem of traffic congestion in cities it seems hardly conceivable that the enormous economic advantage of collective transportation by electric power will not be utilized to a much greater degree in the future than at present. It is true that a much higher standard of convenience and comfort for collective transit facilities is necessary, but compared with community cost of rebuilding our cities for automobile travel, the economic advantage lies all with electric power in urban areas of high travel density.

May it be suggested therefore that the electrical engineer has a great opportunity and a great responsibility in the field of urban transportation—the birthplace of electric power. Not alone as engineers but as citizens of the community is it incumbent upon those in position to understand the intricacies of local transportation to aid in the adoption of sound civic policies. The future trend of development will be influenced by psychological and political factors as well as by economic and engineering considerations. The battle of power in transportation will continue to be waged not alone in the drafting room and laboratory, but in the arena of daily life where the public is the judge and where economic and engineering data may be outweighed by visionary schemes which appeal to the popular imagination.

◆ ◆ ◆

Industry Vs. Technical Education

Industry wants better men; educators want better support. Frank statements by leaders of both contingents are illuminating to young engineers and pave the way for co-ordinated attack upon a common problem.

INDUSTRY WANTS the technical schools to turn out men more soundly trained in the fundamentals of scientific and sociologic knowledge. Against this, the technical schools look to industry for more definite support and greater cooperation in the matter of certain specific educational problems.

Such are the impressions gained from expressions of nationally prominent leaders in industry and education as they presented their views and substantiations at a "Conference on the Relation Between the Industries and the Technical Schools," held at Lehigh University, Bethlehem, Pa., October 16, 1930, in connection with the dedication of the James Ward Packard Memorial Laboratory of Electrical and Mechanical Engineering. Excerpts from several of the speakers appear in the following paragraphs:

F. A. Merrick, president of the Westinghouse Company, undoubtedly sounded the keynote from the industrialist's standpoint when he said ". . . What the industry wants is men who can and will do some one thing better than it has ever been done before . . . who can add something to the sum of human experience, whether that experience has to do with design or manufacture, or research, or selling, or administration . . . and the technical man who is properly qualified and trained and willing to work has no limit to his possibilities in the (industrial) field.

"Industry expects a group of men so selected and so trained in fundamentals and in analysis, and in the application of such analysis to practical problems, that they can develop into the doers of everything needful for the solving of each problem in the whole range of requirements. It does not, however, expect men from the schools . . . to solve every problem concerned . . . much less all of them . . .

"The reasonable expectation of industry is satisfied if, for instance, Graduate A emerges with the capability of developing into the best there is in such-and-such a division of the field, while Graduate B is qualified and fitted for similar development in another perhaps equally important field; and Graduate C for still another field, and so on. The sum of A + B + C is what the educator is expected to furnish. . . . So the indicated procedures should aim to provide first of all a basic training that later would be usefully employed no matter in what class of organization the graduate might find himself . . . .

"The most frequently heard criticism of the technical man is that he is lacking in human understanding and in acquaintance with the world of affairs; and along with these deficiencies very often he is lacking in the exercise of adequate expression in speech or writing, especially on the subjects involving anything outside of purely technical subjects . . . .

"In confessing that there is considerable ground for this judgment it must be remembered that the ordinarily required preparation for a technical course makes great demands on the young man's time and energy. The same thing may be said of his pursuit of the subsequent technical career. All of this makes it doubly important that an early foundation in the so-called humanities studies should have due consideration in making selection among those applying for admission to the technical schools . . . . Post graduate work might in some cases—especially in research—be employed profitably in the schools, though as a broad proposition the real specialization comes only in the actual contact with the school of experience in the industry itself."

Alfred R. Glancy, president of the Oakland Motor Car Company, in echoing Mr. Merrick said in part: ". . . Industry is asking for men thoroughly trained in the fundamentals and with personality, . . . generous in tolerances, and humble; not with the humbleness of acquiescence, but the greater humbleness that is willing to take the suggestions of a better man and use them. . . . They should have disciplined spirits."

Mr. Glancy stated frankly that "engineering departments of many technical industries are carrying heavy quotas of foreign-born and foreign-trained men because these men with their practical foundations of scientific training are capable of great development. Also these . . . men do a more thorough job. They are happy with gradual advancement, which in turn makes for thoroughness of execution. Frequently, after two or three months on the drafting board or a similar time in the shop, our American graduates are discouraged because the glamorous executive positions about which they have heard so much are not immediately open to them."

In reporting upon a personal survey among motor-car manufacturing executives, Mr. Glancy stressed the undesirability of narrow specialization upon the parts of technical students, "for instance, in gas engine design." With equal emphasis, physics, chemistry, mathematics, English, political economy, economics and a "seasoning" of the purely cultural subjects were unqualifiedly recommended.

Matthew S. Sloan, president of the New York Edison Company, spoke with characteristic frankness representing the utilities view: ". . . . We seek men who have attained good academic standing in their classes, but not necessarily the highest. We expect them to know their books and tables, but we expect them to know a good deal more; to know, for example, that books and classroom work are simply a foundation and that some of what they have been taught is already out of date or wrong. We expect them to know how to reason—how to think. We expect them to have curious minds, inquiring minds, eager to acquire information, active to associate it with other information, able to digest it and put it to use. We want them to have initiative and character. We want them to have intellectual and moral as well as physical courage. We want them to have a personality which will enable them to deal successfully with a trench digger or the presidents of the companies. We want them, having information and ideas, to be able to present them clearly and persuasively, orally or in writing.

"We want these men to have a technical education.—Yes, but a technical education which will help them in learning our business, and not one which will send them to us with a lot of theory which they will have to unlearn because it is behind the standards and practises of our business. I am speaking frankly. The practises of our business must always be in advance of what is taught in the classroom because it is impossible for the schools to keep abreast of practises in our industry where improvements are being worked out from day to day. We want technical graduates who have been taught how to learn, how to adapt themselves in the school of trial and work."

Bancroft Gherardi, vice-president and chief engineer of the American Telephone and Telegraph Company, and past-president of the Institute, also emphasized the importance of fundamentals: ". . . What we want are men who can recognize the problems with which they are confronted, study the problems, determine the appropriate action, and then take such action in the right way. For men in the administrative and general engineering departments, these seem to me to be the essential requirements . . . Train the student to recognize the necessity of getting his facts; teach him the best methods of getting them, and train him to interpret engineering data and reason therefrom.

"One of my strongest convictions is that unusual effort may well be made to reach every engineering student to speak and to write a report or letter in clear, convincing English, setting forth the facts, arguments, and conclusions pertaining to the question before him. It is of the greatest importance to an engineer that he shall be able to state in correct and logical form the problem before him, and to enforce his conclusions with arguments which shall be convincing. Such training as this is not merely one in literature, composition, or rhetoric. To present such a report, the problem must

James Ward Packard Memorial Laboratory of electrical and mechanical engineering, Lehigh University, Bethlehem, Penna., where educational-industrial conference was held in connection with dedication ceremonies.

have been mastered and clear thinking must precede clear speaking or writing."

L. Warrington Baldwin, president of the Missouri Pacific Lines, likens the technical school itself unto a manufacturing establishment: ". . . The technical school today is essentially an industry. You may call it a foundry, melting and molding a material which we designate as a student mind into a crystallized and permanent thing we call a matured mind. You may call it a builder, shaping into a permanent structure of many parts the various things we call research and the application of the products thereof. You may call it the creation of an asset we call capital, a salable article or medium of exchange coined from the ore of natural and able mentality and offered for a circulating medium which, if the ore be good and the alloys strong, will not depreciate by usage . . . . .

"If the product of technical schools is to be a factor of increasing value to industry, it will have to insure in its operations the same progressiveness that characterizes industry. This is foremost in importance and cannot be overestimated . . .

"Great care must be used in outlining a course of study for young men looking toward the occupancy of executive positions. They should not be given the idea that a course of study alone will fit them for such positions any more than will a course in art insure that the student will become a great painter or a course in literature create a renowned author or historian . . .

"It should further be impressed upon the student that his diploma is not a magic wand which will open to him the door to success, but that after graduation and the securing of a 'job' and not a 'position' as a start, his progress is almost entirely dependent upon himself, except as it may be modified by fortune or misfortune."

EDUCATORS' POINTS OF VIEW

Paralleling the demands of the industrialists, the educators made some demands upon and suggestions to industry.

Arthur M. Greene, Dean of Engineering at Princeton University, commented upon the limited amount of time available to the technical school in which to educate its students saying, ". . . in this limited time only the fundamentals can be taught, and special details of a particular branch of industry should be given to its new employees by the industry itself, using that which the schools have done as a basis for this further training . . .

"Another thing which we should ask from industry is a constructive criticism of the work which we are doing as shown by our graduates . . . Could not industry in a fair, frank way inform us of any lack seen in our particular men? Of course, as engineers we should like both sides of the picture; and if our men appear to have a proper appreciation of these fundamentals and ability to grasp the new details which are presented, we should like to know of it so that we may carry on in this way which has produced these good results. Records and reports are to be used not only to eliminate faults but to maintain virtues . . .

Doctor Greene suggested that industry make more effort to carry on important researches in and with the cooperation of the laboratories of educational institutions so that students may benefit by contact with practical problems, industry may benefit by additional and independent points of view, and the school may benefit by having the use of special equipment installed by industry for its researches. Continuing he said, “At some of our technical schools cooperative research problems are being worked out by industry and the schools . . . The technical schools have the personnel, the equipment, and the space by which many problems of industry could be solved for those without research facilities; and for those with great facilities, these institutions are the natural places to which to turn for independent, original, or confirmatory work. The schools expect that industry will seriously consider this subject . . .

“The outstanding activity on a fairly large scale by industry, the summer conference for engineering professors by certain large manufacturing companies is one which the schools hope for from industry as a whole

Could not the smaller industrial plants offer summer employment to one or two men from the schools, even though a large conference is not possible? Each school has near it a number of industrial plants into which its teachers would fit.

“One of the requests which my own institution is making of industry is the summer employment of students, particularly for men who have completed the junior year. Many employers have granted our requests, and I now ask if this is not one which industry in general should expect from the schools. This would be for the purpose of giving the student a professional and commercial point of view to bring back to his college work, and at the same time to give the employer a chance to try out a possible employee for the next recruiting season.”

D. C. Jackson, head of the Electrical Engineering Department of the Massachusetts Institute of Technology, pointed out that: “. . . Engineering schools expect industry to recognize the duty of the schools as educational institutions to maintain independence in thought, in subjects and methods of research, and in opinions. In return, the faculties should recognize a duty to refrain from spreading inadequately founded opinions and from dogmatizing in controversial fields . . .

“Engineering schools expect industry to recognize the importance of independent operative scientific research as part of the life of the faculties and students, and to support it with contributions of money and counsel made to those schools which are adequately manned and equipped, to the end that additional knowledge may be disclosed, out of which industry may forge new applications; and also, to recognize the importance of such research as a pedagogical instrument in those schools which are manned and equipped to carry it on properly.

“Engineering schools expect large industrial establishments in their own interest, to pay more attention to the assimilation of recent graduates into the industrial work for which they are employed. With few exceptions the present practise is to fit these new employees into places requiring very limited needs, and to make no provision for such employees to gain (except by chance) an understanding of the accomplishments expected of them, thus leaving them ‘wallowing around’ for months without light or leadership . . . Engineering schools expect that the personnel problem of employing young men who are on the eve of completing formal study in the schools will be dealt with by the employing agents of the industries in a judicious and discriminating manner . . .

“That the public may come to realize the propriety of industry making contributions of generous size to selected engineering schools for the support of independent research in those schools, engineering schools expect that industry will aid in laying before the public a fair statement of the public interest in continued industrial development and invention, and the need

Main floor, electrical end, Packard Laboratory. Mechanical equipment in the distant half and lighter apparatus conveniently placed around spacious balcony; careful planning facilitates maximum student use of equipment provided by a far-sighted industrialist of maintaining independent research in the engineering schools, in order that a stream of results may be available as raw material out of which to mould further industrial development and invention."

An Important Suggestion

One of the most far-reaching suggestions of the conference was voiced by David E. Ross, president of the board of trustees of Purdue University. Mr. Ross urged that: "it is not unreasonable for our higher schools to expect industry to help in the searching out of fine-grade human raw material with which technical education must work . . . If industry builds widely for its own future, adequate provision will be made whereby the brilliant mind-constructing teachers in the universities will have reward and remuneration commensurate to those granted productive industry. Technical education would gain immensely if a certain large proportion of the men who have attained recognized superiority in industry were permitted to return to the university to contribute, as only they can contribute, to the training of the new leaders in our material civilization."

◆ ◆ ◆

Australasia as Seen by an Engineer

South Pacific continent and its neighbor island present many features of interest; glimpses of a few are given here.

By Paul M. Lincoln

Director, School of Engineering
Cornell University
Fellow, A. I. E. E.

FROM HONGKONG to Brisbane, Australia, is a three-weeks' journey—an indication of the magnificent distances which separate Australia from the rest of the world. The latitude of Brisbane in the southern hemisphere corresponds closely to that of southern Florida in the northern hemisphere, and January temperatures are about what one might expect of southern Florida in midsummer. General dryness of the air, however, makes the high temperature quite bearable.

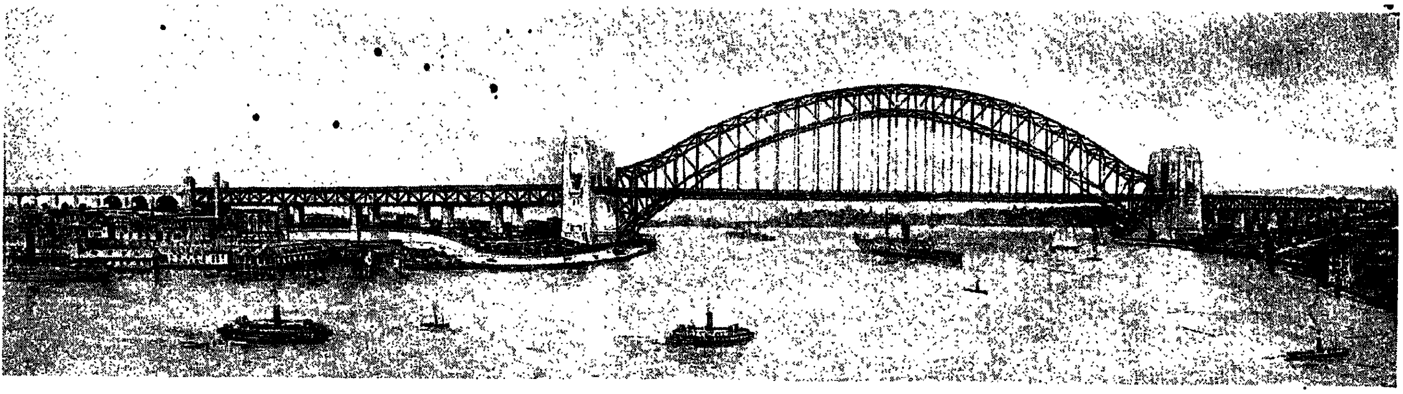
As a northerner travels overland from Brisbane to Sydney, one of the noticeable things about the Australian landscape is the total absence of both the flora and fauna of our northern hemisphere. Practically every recognized plant or animal is an importation from the North. As is well known, some of the transplanted animals and plants have become well-nigh insufferable pests in the southern hemisphere. The rabbit, which to us in the North is probably the best known of these, has multiplied so rapidly in Australia that it has become a distinct menace to the grains and other plant life of that continent.

The cactus is another imported pest: particularly in Queensland has the cactus spread rapidly and occupied lands that otherwise would be available for grazing or cultivation. Its spread has caused much apprehension in Australia and recently a cactus pest was introduced which it is hoped will hold the cactus in check. Still another pest is the blackberry, which is particularly troublesome in New Zealand. Large areas of that country have already been overrun by the blackberry and as yet no adequate means of checking its spread has been found.

Sydney itself, a busy, bustling city of approximately a million inhabitants, has one of the finest harbors in the word—the finest, if one is willing to accept the Sydney citizen's own appraisal. However, since it has been found necessary to throw a bridge across it to the north at a high cost this harbor might in one sense be viewed as a handicap. Rapid growth of the city has made more usable territory desirable and the bridge connecting Sydney to the North Shore is now under construction; its completion is expected some time during 1931.

Another thing about Sydney that is reminiscent of New York City is the torn-up condition of the streets incident to the installation of a subway system. As in many another city, growth has made necessary a better transportation system, and again subways have been selected as the best available means of supplementing existing systems.

In the State of Victoria the development of greatest interest to the electrical engineer is the use of the brown coal at Yallourn, a district about 100 mi. east of Melbourne. This coal bed lies under an overburden of earth only about 30 ft. thick, a condition which permits open-cut workings with resulting nominal mining costs. At the present scene of mining operations the thickness of the coal layer is about 180 ft., but in some parts of the field, borings to the depth of 1000 ft. have shown several superposed beds of this coal having a total thickness of 808 ft. It is estimated that there is available for mining by the open-cut method at least 20,000 million tons. In the area of one square mile set aside for the initial workings, the existence of 150



Sydney Harbor Bridge (Australia), under construction to relieve traffic congestion, reminds one of the famous Hell Gate Bridge in New York.

million tons has been proved, a supply sufficient to serve a 150,000-kw. power station for one hundred years.

The moisture content of this fuel is unusually high, varying from 50 to 65 per cent, and naturally results in a low heat content as compared with the usual black coals. With a 60 per cent moisture content, the calorific value is about 4700 B. t. u. per lb. In spite of the low heat value the small cost of mining makes this fuel an economical source of power. The great problem has been to find the proper methods of burning it under boilers. The little experience that was available was in connection with the development of the brown coals of Germany, and it is only natural that much of the mining machinery used at Yallourn was designed and manufactured in Germany.

The major market for Yallourn power is Melbourne, 100 mi. away. However, some fifty or more other municipalities and townships in the State of Victoria are deriving their electrical power from Yallourn and its associated power stations. Eventually the system undoubtedly will cover a large portion of the State of Victoria.

At the present time, a small amount of water power is being developed and fed into the general transmitting and distributing system, and further water-power developments are contemplated for the future.

By most of us here in the United States New Zealand is considered as being a close neighbor of Australia; hence it is rather surprising to find that the run from Sydney to Auckland is nearly 1500 mi., or four days' sail, equal to nearly half the distance from New York to London. New Zealand differs from Australia in its abundance of water. Snow capped mountains reaching a height of more than 12,000 feet abound, particularly in the South Island. This rough terrain together with the abundance of water gives the country a decided preëminence in the matter of water-power. More than 80 per cent of the electrical energy used in New Zealand is developed by hydraulic plants. Of course in New Zealand as well as in Australia generation and distribution of electricity is carried on as a government enterprise.

New Zealand is divided into some 50 or 60 districts in each of which a "power board" (in every case a creature of the government) has complete authority in the matter of the generation and distribution of electricity. The extent to which the country has been electrified is astonishing; it is stated that at the present time 75 per cent of all possible users of electricity in New Zealand are being served, and that there is hope to increase this figure within a few years to 90 per cent. This really is remarkable when one considers that there are only about one and one-half million people in New Zealand with an area of 105,000 sq. mi. In other words, the average density of population is less than that of the state of Nebraska. In these electrical "undertakings" there is no endeavor to make a profit. Rates for service are so fixed that only cost of service will be met, including of course a sinking fund that eventually will cover the original first cost. This policy explains why New Zealand is able to serve so large a proportion of its sparse population; the fat districts carry the lean.

New Zealand and Australia are almost entirely pastoral; wool, mutton, beef and dairy products constitute by far the greatest proportion of all exports. As might be expected of countries so young and sparsely settled, very little manufacturing is done.

A thing that one cannot but note in both New Zealand and Australia is the strong sense of loyalty to the mother country. Other things being equal, the Australasian will buy his requirements from England or at least from some other part of the British Empire. In spite of this pronounced British preference, however, the prevalence of American automobiles is noticeable. According to personal observation at least 90 per cent of the automobiles in Australia and New Zealand are of American manufacture. To queries as to why this should be, answer was given that the American automobile suited Australian road conditions while the British did not. The Australasian was very frank to say, however, that if he could get a British machine that was suitable and right in price, the trade would go to Britain.

Automatic Operator Improves Efficiency

Because the burdensome detail of maintaining accurately predetermined loading schedules is more than present-day minimized operating forces can handle, seldom are hydroelectric generating stations operated at maximum efficiency when under manual control; automatic control equipment subject to manual regulation solves the problem.

By S. Logan Kerr

Research Engineer,
I. P. Morris & De La Vergne, Inc.,
Philadelphia

GREATER EFFICIENCIES in hydroelectric plants must come from plant design and operation rather than from further refinements of design in the hydraulic equipment itself. The single important exception to this is to be found in the development of a new type of propeller turbine with automatically adjustable blades, the development and use of which is an important step toward bringing low-head plants to the relatively flat efficiency curve which hitherto has been found only in the medium- and high-head installations.

Operation studies of a number of plants show conclusively that the average operating efficiency rarely equals the maximum over-all efficiency of the station. In one of the newer large hydroelectric plants in the East, the over-all efficiency of the station was found from tests to be approximately 90 per cent, whereas detailed analyses showed that the maximum normally obtained in daily service was only about 80 per cent. The 10 per cent margin between these two figures was traced directly to inefficient loading of the plant and inefficient load distribution between the various units within the plant.

Other factors, such as the unnecessary lowering of the maximum operating head in the excessive drawing off of the small ponds and storage reservoirs, greatly impair over-all station efficiencies. Attention directed to these factors indicates a fruitful source of study for improvement in operating practise with recovery from losses to proportions hitherto unsuspected.

Hydroelectric stations of course must be operated with a definite understanding of the capacity of the station's available stream flow, the market for power, and the operating characteristics of the system to which its power is being supplied. For a plant in service, the general operating problems in so far as they are considered with respect to economy may be classified as follows:

1. Economic load distribution between units for any given station load and combination of generating units.
2. The economic output of the station corresponding to the points of maximum efficiency for the various combination of units.
3. The maintenance of the economic number of units or combination of units in service for any given load on the station.
4. The maintenance of maximum operating head and conservation of flow.
5. The control of pond levels with respect to flow when surplus water is available.
6. The maintenance of sufficient system reserve capacity to provide for system requirements, to be operated in parallel with the system and carried at a minimum cost. This may be divided into two types; reserve for immediate availability and reserve for delayed availability.
7. The maintenance of a fixed draft of water from storage reservoirs or through run-of-river plants, to supply the proper water balance on a given stream where more than one station is installed, in order to provide for plants farther down the river or to absorb the discharge from plants above the one under consideration.
8. Automatic frequency control to maintain constant frequency with the possible refinement of maintaining constant average frequency where electric timekeeping is a factor.
9. Automatic power-factor correction to improve line and distribution voltages and power factor within the limits of the machine capacities and by utilizing surplus machine from time to time as synchronous condensers.
10. The possibility of making use of flood water to increase the annual plant output.
11. The economy of spilling water over a fixed-crest dam under low-water conditions to secure full maximum operating head.
12. The possibility of increasing net plant output by decreasing the output of certain machines below the point of maximum individual efficiency.

The first five of these classifications deal principally with the hydraulic characteristics of the plant itself; Items 6 and 7 deal with the relation of the plant to system operation; and Nos. 8 and 9 may be classed as effecting the type of service rendered by the power company. The last three were suggested in a discussion presented by C. F. Merriam of the Pennsylvania Water & Power Company, Baltimore.

Most of these items have been given some attention by operating engineers but in most cases further attention could be given to advantage. Too much emphasis can not be laid upon the desirability of greater utilization of field-test results as a basis upon which to achieve better standards of operation and increased efficiency of utilization of the plant itself. Field tests can be made cheaply and simply in practically all plants by either the Allen or Gibson methods; and where these methods cannot be applied it usually is possible to employ current meters with a reasonable degree of accuracy provided sufficient care is used.

From "Automatic Operator for Economy Control," presented at the A. I. E. E. Middle Eastern District Meeting, Philadelphia, Oct. 13-15, 1930.

For purposes of determining the proper loading of the individual units, and the proper combination of units for maximum over-all efficiency for any given station output, accurate determination of unit-operating characteristics should be prepared along with schedules of economic load distribution between the units. In existing stations, a careful analysis of operating records taken from the daily log sheet will provide the bases for these determinations. For new plants, acceptance test data will serve; and where accurate test data are not available, it is possible that a combination of the manufacturer's test curves and the manufacturer's expected curves, combined with power-gage-opening tests on the actual installation, will provide sufficient information from which to prepare operating charts for units having similar characteristics.

For units with dissimilar characteristcs—which of course include units of different specific speeds and capacities, and occasionally units having the same capacities and speeds but built by different manufacturers—field efficiency tests are the only dependable source of information.

With the station and unit characteristics determined, an over-all schedule of operation may be prepared which will specify for each load on the station, the number of units required to carry the load, the proper combination of units, and the proper loading of each unit in order to maintain the best over-all efficieny. Based upon an estimated percentage of adherence to such a schedule, the question of load factor, load demand, and the rate of draw-down of the forebay, can be studied in their effects upon the maintenance of the maximum head. In cases where appreciable pondage or storage is available, a nice balance may be worked out between the permissible rate of draw-down during the demand hours and the building up of the head-water level at night. With low- and medium-head plants, particularly in a series development without head overlap between plants, it is of great importance in order to prevent loss in output and efficiency, to maintain the maximum possible operating head.

The factor of system reserve capacity also is one which should receive abundant attention and careful study to determine a reasonable margin of reserve to protect the system adequately against any shortage of power during sudden demand periods and at the same time to avoid excessive waste water arising from carrying too much reserve in parallel with the system. Because of the requirement of shutting down and starting up units at the proper time this phase of operation introduces still another burden upon the operating staff; also, because of the necessity for maintaining sufficient capacity in service to care for the normal operating emergencies which would cripple service if such reserve capacity were not immediately available, it introduces a serious responsibility upon the part of the system load dispatcher.

Studies of actual cost of carrying reserve capacity in any one plant, or with any combination of units can be made. On the same basis additional studies will indicate the desirability of operating units as synchronous condensers or merely as reserve capacity floating on the line. At most plants some saving can be realized by motoring the units from the line with the wheel gates tightly closed and the runner vented so that it operates in air rather than in water. The difference between the cost of maintaining the reserve by these two methods and that of having surplus units of light-load capacity represents a marked saving if the element of availability is assured.

It is self-evident of course that all of these factors have been given, and are being given, attention by operating engineers; the one element, however, which has hampered seriously the achievement of ideal economy in operation has been the necessity of depending entirely upon the human element. Further aggravating this same difficulty has been the tendency to reduce operating forces to a minimum, resulting in increased duties and responsibilities for the individual operators. Thus, the operator's attention has been forcibly directed to the prime requirement of maintaining continuous service, the question of economy necessarily becoming of secondary consideration.

The burden of maintaining accurate loading schedules, and of giving careful attention to each of the factors outlined at the beginning of this article, will pass beyond the realm of possibility for manual operation unless the present trend is reversed with a considerable increase in operating staffs and provision for rigid supervision. It is in this connection, because of the operating efficiencies that can be achieved with it, that automatic-control equipment has come recently into prominence.

With the development of automatic-control equipment the whole aspect of these operating problems changes, since the human element no longer becomes the limiting factor. Analysis of the economies of operation form the basis of preparation of ideal schedules adapted to the particular system requirements, and the application of specially designed automatic-control equipment permits the rigid enforcement of these ideal schedules, eliminating the losses which must result from the inability of operators to follow these schedules continuously.

One of the first applications of this principle of operation was made at the 87,000-hp. Norwood plant of the Carolina Power & Light Company, where the problem presented was to obtain the maximum operating efficiency out of two high-speed, large-capacity units with relatively steep efficiency curves, and one somewhat smaller slow-speed unit of a relatively flat efficiency curve. Design studies showed that with the units of different capacities a higher average efficiency could be realized for the plant over its entire range of output than would be possible if all three were of the same high-speed characteristics. Economic load schedules showing the proper distribution of load between the units necessary

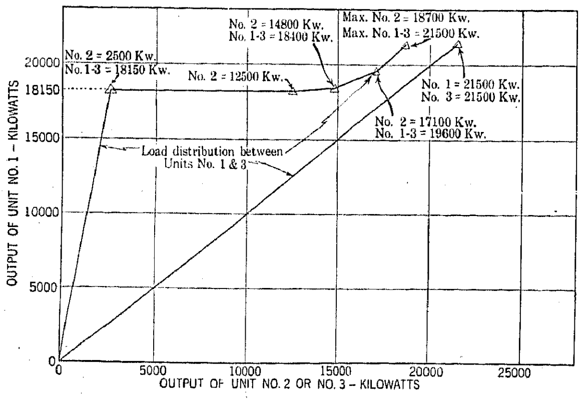


Fig. 1. Ideal loading schedule as calculated for the 87,000-hp. Norwood plant of the Carolina Power & Light Company

to maintain a maximum combined efficiency indicated a rather complex problem; at least from the standpoint of manual operation. It was demonstrated that slight departure from the proper loading schedule would result in appreciable loss in efficiency.

At Norwood the equipment as actually installed consists principally of a multiple bridge circuit, one side of each bridge being a manually-adjusted standard potential and the other side a potential in proportion to the unit output. By basing the standard potential relations upon the ideal schedule for load division between units, the balance would be secured at a point at which the load on the various individual units would be brought to the standard as manually set; this in turn agreeing with the desired load distribution between units. A single dial, subject to the control of the operator, accomplishes an economic load distribution between any combination of units in service. Additional attachments make for more flexible operation but introduce no change in the basic principle involved.

Study of the curves in Figs. 1 and 2 will reveal what application of automatic control can accomplish to relieve plant operators of the burdensome routine; also what can be accomplished by maintaining the highest possible operating efficiencies at the station. The circles show the results of manual operation while the triangles represent the operation with the automatic control in service. In Fig. 2 the upper envelope curve represents the maximum over-all efficiency of the plant and it is of some interest to note how accurately the automatic operator follows it as indicated by the close proximity of the triangle. The approximate figures indicate that in so far as its relation to the ideal operating curve is concerned, on manual control the production efficiency of this station was approximately 90 per cent. With the automatic operator the average operating efficiency has been raised to a point in excess of 96 per cent and has been kept as high as 98 per cent for appreciable periods of time. The difference between the ideal operation represented along the upper envelope curve of Fig. 2, and the actual results secured at the station, include all losses due to the incorrect number of units in service, as well as the losses introduced by maintaining system reserve capacity. The actual loss incurred by incorrect distribution of the load between the units while under automatic control has been materially less than 1 per cent.

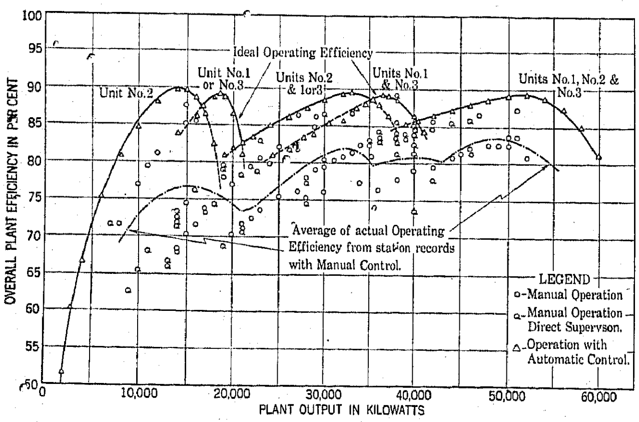


Fig. 2. Over-all plant efficiency curves for Norwood plant

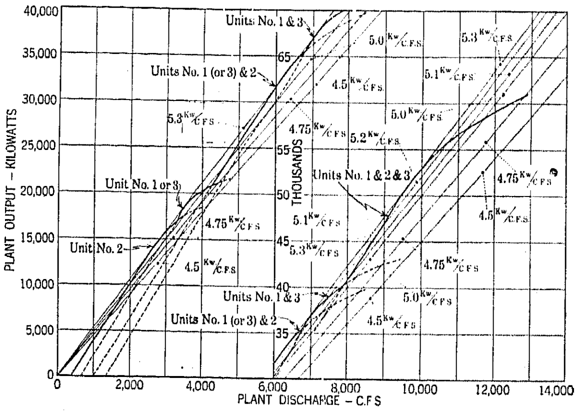


Fig. 3. These curves, showing power output with respect to water discharge, simplify the work of the load dispatcher

At the Norwood station daily efficiency log sheets are carefully kept to furnish the basis of detailed analyses through which the operating engineers may determine the reasons for production losses—accurate records upon which to base their efforts, and by which to direct attention to the elimination of losses.

To simplify the work of the load dispatcher, the curve sheet reproduced in Fig. 3 was prepared representing the station output with respect to station discharge and with superimposed radial lines representing uniform increments of the kilowatts obtainable for each sec-ft. of water passing through the station under the rated head at which the plant normally operates. These radial lines intersect the power-discharge curves at various points, and both the load dispatchers and station operators can see at a glance the zones of desirable operation.

By means of these curves and log sheets, combined with the assurance that whatever load is dispatched to the Norwood station will be carried in the most economic manner possible, the system operators and load dispatchers were provided with a more efficient tool with which to work. This resulted in operating efficiencies and reflected exceptionally large savings to the power company over and above the very best possible with manual operation.

Another interesting application of automatic operator equipment was made more recently at the Morony plant of The Montana Power Company, near Great Falls, Mont. Morony was designed to effect system control and automatic frequency control equipment was installed as part of the hydraulic turbine contract. Both units in that station are of the same size and operating characteristics, and it was estimated that the requirements for maintaining frequency on the Montana system would call for the continuous operation of both units through a range of output from one-half to three-quarters of their full-load rating. As the load on that system is subject to variations not easily predicted, question arose as to the loss of efficiency emanating from the operation of two units at less than one-half of their individual capacities where the load could be more efficiently carried on a single unit.

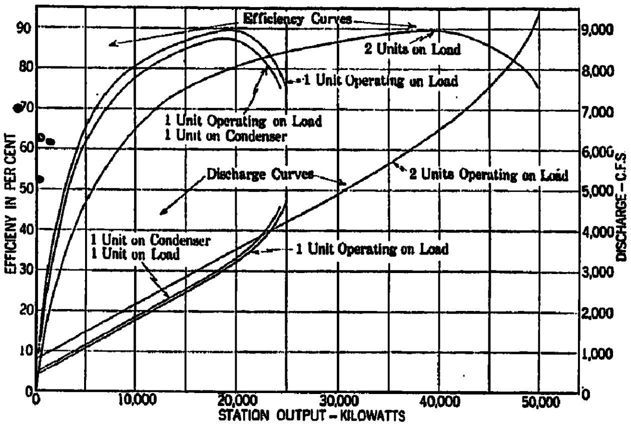


Fig. 4. Performance of the Morony plant of The Montana Power Company under control of an automatic operator

With the application of automatic frequency control to Morony, a further step was made in the development of automatic economy control by arranging special equipment automatically transferring one unit from operating on load to operation as a synchronous condenser, where the point had been reached of one unit alone carrying the particular load demand of the station more efficiently than could the two units together. From Fig. 4 it may be seen that for an output of less than about 23,000 kw. it is more efficient to run a single unit than to operate both units. Under this condition it was impracticable to shut down one of the units because it was necessary from a system standpoint that the surplus power of the two units be immediately available to care for sudden load demands. This requirement led to the development whereby one unit when its generating capacity is not needed is transferred automatically to synchronous condenser operation. By the use of efficient automatic air vents, the power required to drive one unit as a synchronous condenser is held to very small limits, as shown by actual tests and as reflected by the curves of Fig. 4. Provision was made also to return this reserve unit automatically to load service whenever it was required, this to be done either at a very slow rate for normal service, or at a very rapid rate for emergency conditions.

Fig. 5 represents the economic analyses of Morony station with the saving effected by the automatic control plotted with respect to station output. By the operation of one unit as a condenser and one unit on load, based upon the utilization of the same water flow as would be required for two units carrying this same load approximately 24,000 kw. in capacity are saved. According to the latest studies this represents slightly more than $7 per hour saving (3 mills per kw. hr.) for each hour that the plant is operated at an output of less than 18,000 kw. Since storage facilities are available, these same savings can be translated into savings in discharge as shown.

The possibilities of extending this type of control to other applications is at present virtually unlimited. The same principles that have been outlined in connection with the application of automatic economy control to individual plants are readily adaptable to the operation of groups of plants, including a combination of steam-electric and hydroelectric plants.

Application of automatic economy control to electric power generation requires an intimate knowledge of system characteristics as well as prime mover characteristics. The success of automatic economy control installation can reach its highest degree only through complete cooperation between the manufacturer and the operating company and by maintaining an impartial attitude in regard to the equipment to be used, its application and its limits. To secure the ultimate aim of the highest efficiency of power generation possible with the installed equipment the engineering of design and application must be carried on with these principles in view.

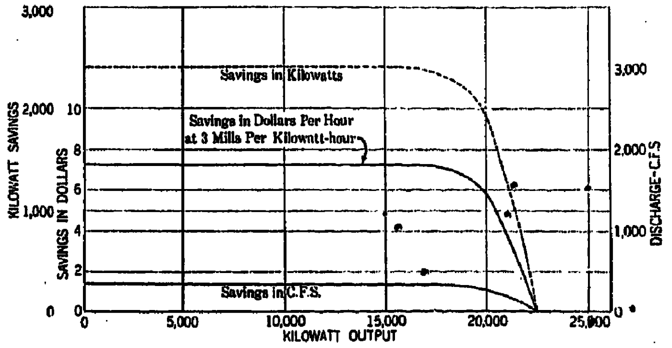
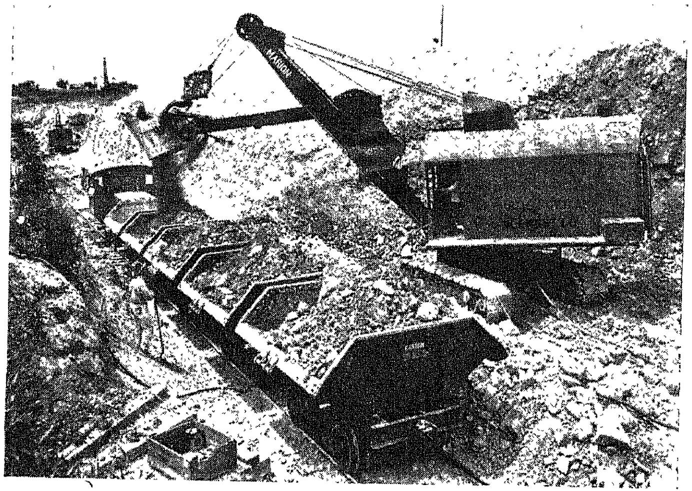


Fig. 5. Automatic operation at Morony translated into savings

Electricity in the Cement Industry

By R. H. Rogers

General Electric Company
Schenectady



Electric shovel in cement mill quarry

Practically completely electrified, the cement producing industry uses 2½ billion kilowatt-hours of electric energy annually in the production of its $275,000,000 output of 175 million barrels.

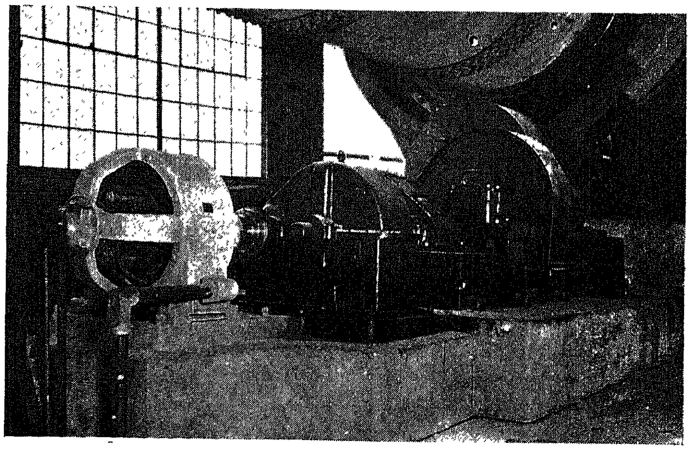
AN INDUSTRY which uses 2½ billion kilowatt-hours of electric energy per year at practically unity power factor, and at the highest load factor known to the larger industries, presents many interesting features to the electrical energy. In the Portland cement industry the use of electric power in new plants is becoming universal. The greater part of it is purchased power and all of it is used subject to extraordinary efforts to get the most out of every kilowatt-hour.

A typical modern cement plant has a daily output of about 3,000 bbl., costs 2½ million dollars, employs some 200 men, and uses from 45,000 to 60,000 kw-hr. each day. The total investment in this highly competitive industry in the United States is some $650,000,000 and the value of its annual output of 175,000,000 bbl. (700,000 94-lb. sacks) amounts to $275,000,000. Major plants of this industry, totaling some 160, are scattered through 33 states in the Union. According to Cement Association estimates, 33 per cent of the annual manufactured product is used for road construction, 25 per cent for building, 15 per cent for rural uses, and the remaining 27 per cent is scattered over some five classifications, the last of which covers bridges, river and harbor works, dams and water power projects, and takes only 4 per cent.

Commercial Portland cement is more or less a varied mixture of tricalcic silicate, dicalcic silicate, tricalcic aluminate and tricalcic ferrite. The alumina and iron oxide act as fluxes so that the lime and the calcium can combine at workable temperatures. Excluding the normal 5 per cent of impurity and the 2 per cent of gypsum added as a retarder, ordinary cement contains about 65 per cent lime, 25 per cent silica, 7 per cent alumina, and 3 per cent iron oxide. Its manufacture involves many operations and electric equipment contributes to expeditious handling and control throughout the processes.

In a typical installation raw materials are taken from the quarry by electric shovels, hauled by electric trains to electrically-driven crushing plants whence the materials go through various grinding, handling, and mixing processes, all electrically controlled. Slurry, the output of the wet process tube mill, is pumped to storage basins and correcting tanks where a chemist maintains the working stock at the desired chemical status.

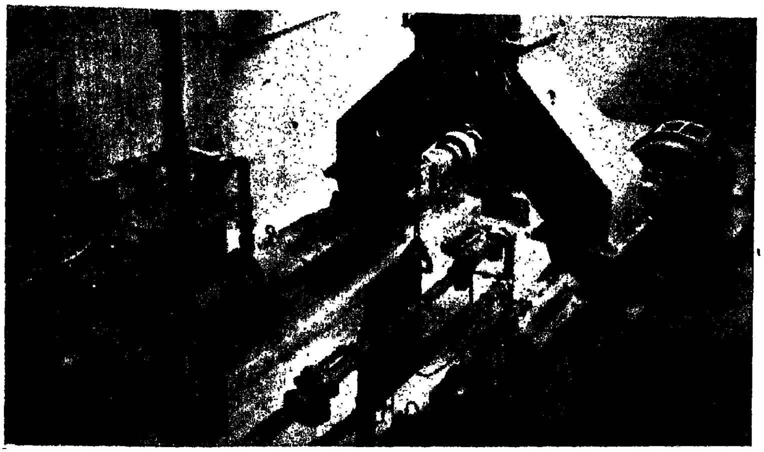
Gigantic tubular revolving kilns, some as large as 12 ft. in diameter, 350 ft. long, and weighing more than 400 tons—by far the largest moving pieces of machinery in the world—receive the slurry for heat treatment. To stimulate a natural flow of its contents, the kiln is inclined at a pitch of approximately ¾ in. per ft. and to keep its contents duly agitated it is revolved at speeds varying from one-half to one rev. per min. About



Adjustable-speed, 75/100-hp., 230-volt, d-c. motor driving kiln through 900:1 reduction gear

---

Presented at the A. I. E. E. Southern District Meeting, Louisville, Ky., Nov. 19-22, 1930. Full text printed herewith.



Cement pumps handling cement from dry grinders to silos; driven by 60-hp. 900-rev. per min. induction motors

three hours are required for the material to pass through the longer kilns from the stack end to the firing end, during which time it meets with increasing temperature up to 2,900 deg. fahr.

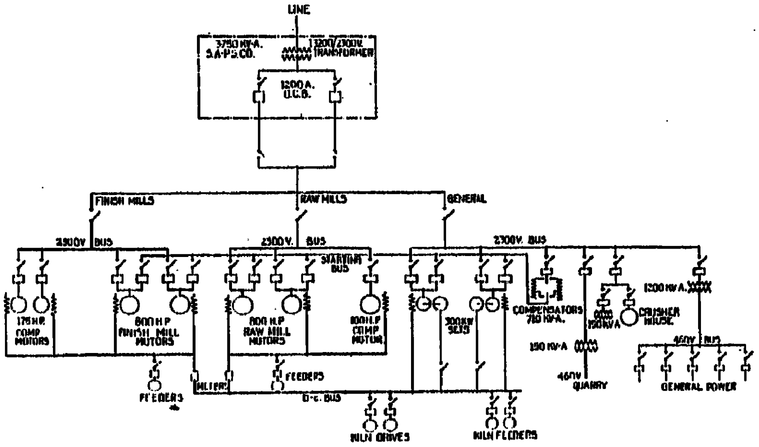
In its passage through the kiln, the slurry is gradually raised in temperature through a zone of chemical reactions to a point of fusion, the product of which is clinker about the size of ordinary marbles. This white hot clinker then passes through long cooling drums to storage where it may be kept indefinitely—even outdoors since it is impervious to moisture. It is hard enough to scratch glass, dark brown or black in color, and bears no physical resemblance whatever to either its raw material ancestors or to the Portland cement which it will be when finely ground.

From the pulverizing tube mill the highly chemically active grey powder—Portland cement—is pumped electrically to storage silos from which it is reclaimed for shipment.

From the central station load standpoint, the cement mill is attractive because it runs through the 24-hour day, often operating as much as two years without shutdown. A plant having a capacity of 3,600 bbl. per day will have a connected load of about 6,500 hp., and the small percentage of idle equipment means a load factor exceeded by few, if any, other industrial loads. Further, the commonly used synchronous motors facilitate power-factor control, adding to the attractiveness of the load. In spite of the fact that waste heat available from the kilns is sufficient to operate a power station of ample size to serve the mill, power usually is purchased. Although many waste heat plants are in operation, advantageous power contracts available in recent years, together with a desire on the part of the cement companies to devote all available capital to the production of cement, have tended to suppress the tendency to install waste-heat boilers and turbine-generating plants.

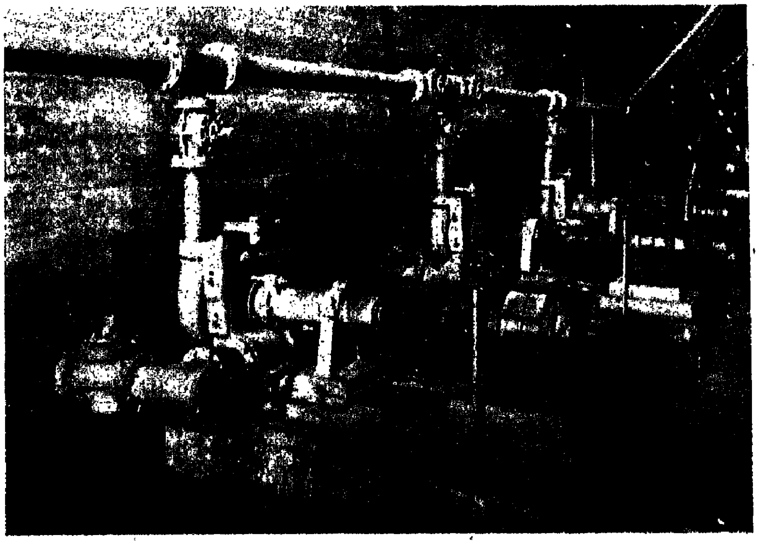
In cement mills at least three common arrangements of electric power distribution are in vogue: (1) A 2,300-volt secondary system with small 2,300/440-volt transformers scattered about the plant at convenient low-voltage centers; (2) separate transformers with 2,300- and 440-volt secondaries placed at the substation; (3) transformers with secondary windings for 2,300 and 440 volts.

The present tendency is to concentrate all circuits at the main switchboard and to control all of the larger motors throughout the plant from that point. Rigid demand specifications common in power contracts make desirable the avoidance of peaks and this is done in some instances by having all heavy motor starting executed by the switchboard attendant, upon signal from the machine operator. This enables the switchboard attendant to watch his demand meter for an opportune moment, a practise which permits full-voltage starting on even the largest synchronous motors, thus simplifying the control and reducing control investment.



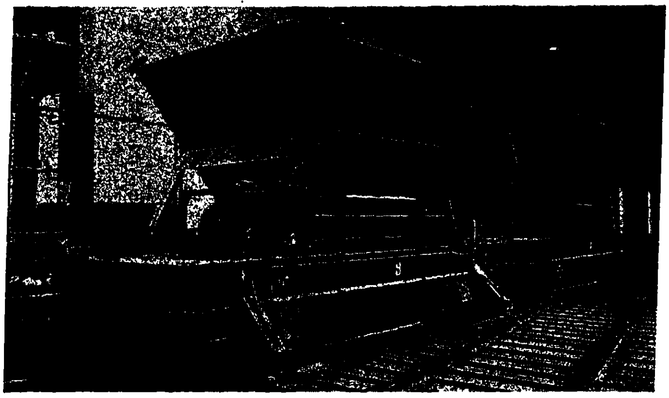
Circuit lay-out used in one prominent 3,600-bbl. mill; arrangements vary widely in different mills

On the main switchboard, some newer mills have installed automatic peak and demand limiters which function by cutting off temporarily certain preferred



Battery of 4-in. slurry pumps driven by 30-hp., 1,500-rev. per min., 440-volt, 25-cycle motors loads when peaks threaten, as well as cutting off larger banks of motors when the 15-min. demand limit is threatened. Air compressors used in a mill may involve as many as four 175-hp. synchronous motors, and solenoid-operated unloading valves are used often to alleviate impending peak conditions for short periods of time.

Another refinement successful in automatically holding the plant power factor at unity is accomplished by arranging the power factor meter to control the field strength on an excitation motor-generator. With a falling power factor this arrangement permits the generator field to be strengthened and the resulting increased excitation on the synchronous motors driving the tube mills tends to restore the desired power factor.



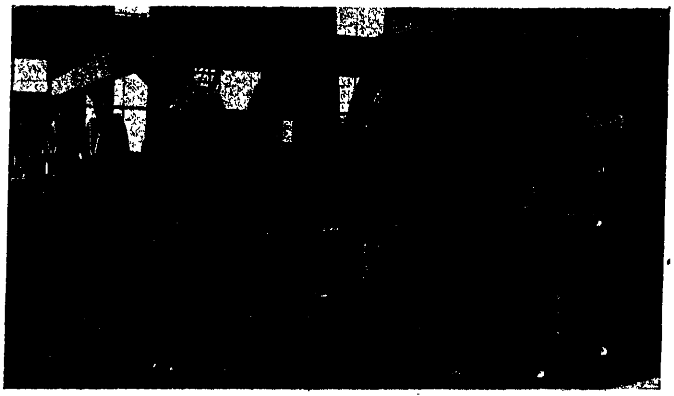
Side-dump transfer cars each operated by two 75-hp. 250-volt motors; motor-driven air compressor on each car

Diverse characteristics of the motor loads in the cement mill make necessary the use of many different types of motors, including adjustable-speed, d-c., wound-rotor induction, squirrel-cage induction, and synchronous motors. For kiln drive and for various types of material feeders requiring a wide range of adjustable speeds, 230-volt, d-c. motors are used. Feeder motors most commonly are 5-hp. open-type units, while kiln motors may be rated at from 50 to 100 hp. Controls for the various motors are concentrated in groups at convenient points so that the kiln operator may control the slurry or dry feed, the coal feed, the kiln rotation, and other related operations.

Electric power shovels are meeting with much favor in cement mill quarries, and those subject to heavy work are almost sure to be operated on generator voltage (Ward Leonard) control. On such shovels there is a motor-generator set, either synchronous or induction, with three d-c. generators, one each for the hoist motor, the swing motor, and the "crowd" motor. Operation and reversals of these motors are controlled solely by the strength and polarity of the fields of their generators, a system which enables the shovel to do a tremendous amount of work in such a smooth way that maintenance no longer is a heavy item in shovel operation. On some properties electric traction is used, and of course d-c. motors carry the burden. Self-propelled side-dump cars, each hauling a trailer, are used at one prominent plant.

Wound-rotor induction motors are used on heavy duty equipment, such as quarry slope hoists, rock crushers, hammer mills and similar equipment, where the current inrush to a squirrel-cage motor would be too great for full voltage starting or where graduated acceleration is desired. These motors are used also for adjustable varying-speed service, such as required for kiln drives, by using constant duty resistors in the secondary circuit. Large motors of this type are operated from the 2,300-volt circuit, while the small ones operate on 440 volts. Squirrel-cage motors of two types are used, but the normal single squirrel-cage type greatly predominates.

In the modern cement mill synchronous motors account for the greater part of the power applied. Normal-starting-torque synchronous motors are used on the d-c. motor-generator sets, air compressors and similar equipment. Tube mills—huge revolving cylinders, in the larger sizes each containing perhaps 100 tons of hard steel balls or grinding pellets in addition to its load of clinker—require from 400 to 900 hp. to drive them at 20 rev. per min. These mills offer a starting load often as high as 160 tons, representing a motor load of from 125 to 180 per cent of normal.



"Super-synchronous" motors provide for full-load starting; the four 800-hp., 180-rev. per min., 2,200-volt motors drive two mills for finish grinding

For this particular duty "super-synchronous" motors were developed. This type has a stator mounted on trunnion bearings and surrounded by a band brake. When it is desired to start one of these excessively heavy loads, the brake is released and the stator brought up to synchronous speed while the rotor and its load are standing still. This makes available the whole normal pull-out torque of the motor for starting the tube mill load and, as the brake is applied gradually, the stator slows down and the rotor speeds up. Of course, the sum of the stator and the rotor speeds always is synchronous speed. After from 10 to 20 sec., as dictated by permissible current limits, the stator is brought completely to rest and the motor thereafter continues to perform as a normal synchronous unit. The brake may be applied either by hand or by a direct-connected pilot motor set to operate at a predetermined rate. In common with the other synchronous motors the power factor of these machines may be adjusted to suit the power factor demand of the plant. Normally, these large motors are started from a reduced voltage bus energized through an auto-transformer or compensator, although in some of the new mills they are started direct on full voltage.

High torque synchronous motors are being applied with good results to tube mills where the power system is adequate to stand the current inrush incident to eight- or ten-second starting. The motors have double squirrel-cage or amortisseur windings, which affect the starting torque and starting current just as the same construction affects a squirrel-cage induction motor. This type of motor presents the simplest form of synchronous motor drive for hard-starting loads, since it requires no clutch or special mechanical construction.

In a 3,600-bbl.-per-day cement mill of modern design there will be about 3,000 hp. in induction motors and 3,500 in synchronous motors. Power factor of the induction motor division will range from 0.82 to 0.85, since all of the motors are fairly high-speed units and carry practically full load, while synchronous motor power factors, of course, are controllable. A common practise in one mill is to operate all of the smaller synchronous motors at unity power factor and to operate four 600-hp. units at 0.90 leading. This results in 3,000 hp. operating at 0.82 lagging power factor, 1,000 hp. at unity power factor, and 2,400 hp. at 0.90 leading power factor.

Continuous operation is of vital importance in several of the steps in the manufacture of Portland cement, and extraordinary precautions are taken to avoid shutdowns. Duplicate units, high class wiring, ample sizes for all equipment, high class supervision and careful maintenance make possible continuous runs of as long as 23 months. After such a period drastic renewals and other maintenance measures are executed to make possible another long and uninterrupted period of production.

Safety to personnel is provided for in the cement industry to a degree not found in many other industries. This attitude is reflected in the entire electrical installation accounting for the prevalance of push-button magnetic control for the mechanical safe-guarding of live parts of motors and control and for the strict enforcement of rules limiting changes or adjustments to electrical equipment to properly qualified persons.

A few years ago cement mills were considered to be particularly hard on electric motors and similar equipment because of the prevalence of abrasive dust. Corrective measures have been so extensive and successful, however, that no extra precautions now are needed to insure successful operation of electrical devices in a cement mill. In fact, motor generators, air compressor motors, large mill motors, and in some cases even the switchboards themselves are installed out in the open in the mill room, a place where in the older mills the dust was the thickest. Today, a cement mill may be made as clean as a food producing plant.

◆ ◆ ◆

What of the Foreign Job?

In the new and rapidly developing countries lie great opportunities for speedy advancement, so attractive to the young engineer; but forethought is necessary if such a step is to be taken advantageously.

By Percy H. Thomas

Consulting Engineer, New York
Fellow, A. I. E. E.

SOMETHING mysterious, something appealing to the imagination of a young engineer, is to be found in the contemplation of a "foreign job." The idea of going abroad among a group of people perhaps somewhat backward in latest engineering and construction methods, and helping them to create a record-breaking mining plant that will earn large profits; or, to install a far-spread and efficient power system to bring from high mountains electric current for a great city with incidentally a large financial nest egg,—is enough to stir the blood of any young, ambitious engineer. This after all is as it should be.

When, however, a young man with a few years' experience in practical engineering, asks for advice as to whether to seek a job abroad or to stay at home, the impulse is to recommend that he stay at home. For this there are good sound reasons; the chief one, that experience has proved that the goal pictured by the imagination of the young man is seldom achieved. Conditions involved in scoring a conspicuous success in foreign engineering fields are many and exacting, and few men have the requisite qualifications. Not many, however, realize their own limitations, nor the difficulty of maintaining a proper perspective in new surroundings. Once a man is launched in a foreign country on a three-year contract a change of berth is no longer easy. Nevertheless, for the right man this service abroad offers inviting opportunities.

There are two types of service to be considered. In the case of the man from "the States" the simpler and more usual undertaking is the signing of a contract with a large construction or operating company, controlled from the home country—a job somewhere in Mexico or South America. In such a case, the man goes among people of his own kind—speaking the same language, with the same background, and living the same sort of life. All matters of transportation, housing, sanitation and health, and the regularity of pay day are company provisions. The real effect of the situation, however, is to give opportunity for intensive technical work, free from distraction and with a good chance to use ingenuity and resourcefulness in overcoming new or locally adverse conditions. There is a chance to evidence intelligence, grit, and character; and two or three years in a foreign country under usual conditions will go far to develop all these qualifications. It is remarkable how one's personal characteristics are stressed; always liquor temptations must be met, and when abetted by example, homesickness, and physical exhaustion it becomes insidious and hard to resist. The success and promise of many a young man has been destroyed by overindulgence.

Also, away from the society of women acquaintances, it is difficult to satisfy a longing for society. On the foreign job women are few and most of those present are married. With the persons assigned to work with him a man often finds himself thrown with unpleasant and uncongenial personalities; this will be trying and frequently irremediable.

Conditions are usually even more difficult for a man who takes his wife with him, for the limitations of such a life weigh more heavily upon her. Lack of conveniences, absence of the relaxations and diversions to which she is accustomed, and the long distance from relatives and friends, are trying, especially since the woman does not have the stimulus of the job's constructive work. And discontented wives may cause real difficulty. But there is another side to the woman's work on the foreign job; a tactful, good-willed woman can do wonders in brightening up camp life and in organizing social activities. In fact companies depend upon a sufficient proportion of this type to keep the spirits of their men normal.

On a foreign job, advancement in authority and personal development are rapid, and a man may rise far in three years. Ability and adaptability count; and further, a man usually gets a wide variety of experience.

At the end of the first contract, the difficult question arises whether to stay or return home? In the latter case there is usually little difficulty in picking up the home threads, the period of absence not having been great. But for the successful man, with offer of more pay, more responsibility, more interesting work, and a feeling of partnership and loyalty for the enterprise, the temptation to stay is strong. Generally, if a man takes his second contract he has crossed his Rubicon and is likely to have a more or less permanent stay. But if he wishes to marry, the question of finding a wife is a formidable one; some find girls of their own nationality on the job; some marry women of the adopted country, but ordinarily, the choosing is under unfavorable auspices.

When the family begins to grow up, the question of schools increases the difficulty, and usually as they reach their late "teens," the young folks are sent back to the home country. The sequel is that when they arrive at college age or even later, there is effort for the return of the whole family. Then the engineer finds himself out of touch with home conditions and former friends. Very few succeed in placing themselves to advantage, some obtain only inferior positions, and not infrequently, a man with financial obligations must return if he may, to the old job.

It is sometimes supposed that companies pay exceptionally high salaries to engineers going to foreign jobs; this is a mistake, for salaries are likely to be rather less than more. It may be said, however, that on the foreign job it is comparatively easy to save a large part of the salary, and this, in the course of years, may amount to a material sum.

The second type of foreign service is the engineer who goes to stay in the new country; to develop with its life and industry. Only those exceptionally fitted and very sure of their ground should consider this course. At the start it is difficult to picture clearly the process and outcome, but once the die is cast it will be hard to turn back, even though many periods of doubt and regret may arise.

Success will lie in entering whole-heartedly into the life of the country and adopting its ways and ideas; not on sufferance, but with approval and appreciation. In civilization, point of view, mode of living, use of leisure, and so on, the people of a foreign country are apt to contrast strongly and unfavorably with those at home. It should not be forgotten, however, that their customs may be different rather than inferior; that life and happiness are complex, and that after all only a few of the opportunities of pleasure and culture offered anywhere may be embraced. While one life may excel in certain things, another may lead in others. Genuine success must be based upon accomplishment, friendships, and appreciation of one's neighbors. Human nature is the same the world over and it is a fact that if one treats people kindly, appreciating their good points, assisting in their enterprises, training oneself in their language, studying their literature, and being generally sympathetic, the reward will be ample.

It is the new and rapidly developing countries wherein lie the coming generation's opportunity for service and advancement. Splendid possibilities for competent individuals as representatives of home companies exist in foreign countries, but to hold the confidence and sympathy of the native men of affairs and at the same time serve the best interests of the home company is no mean achievement.

Small Alternators now Fully Automatic

By Earle R. Wetzel

Electrical Engineer, Kohler Co., Kohler, Wis.
Associate A. I. E. E.

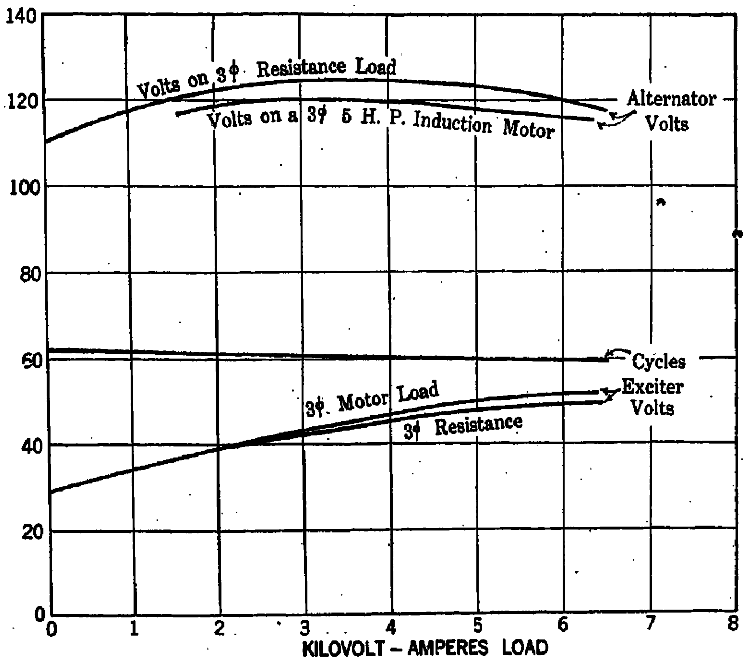
FULL-AUTOMATIC alternators with inherent voltage regulation are now available in 5- and 10-kv-a. sizes. These units have been designed especially to be used in connection with small engine-generator plants where an a-c. supply is desirable. With this equipment a distribution system may be of standard two- or three-wire construction in which every switch operates as a remote-control device for operating the plant without special control circuits.

In the design of this machine difficulties formerly met in connection with inherent regulation have been overcome. Armatures for both alternator and exciter are mounted on a common shaft carried on a single set of bearings. Further to simplify construction the two sets of field poles are mounted in a single frame. The resulting combination machine has a voltage regulation nearly the equivalent of a compound-wound d-c. generator, and achieves this end without manual or sensitive automatic devices.

The two armature cores are built from standard laminations and assembled on a common shaft with slots in approximate alinement. Each exciter armature coil is form-wound with a definite number of long and short turns with a continuous conductor. Short turns are lap-wound in the usual way in the exciter slots only, while the extensions constituting the long turns are laid simultaneously in the alternator slots. Alternator slots are only partially filled with the long coils from the exciter armature and in these slots, the alternator coils are assembled subsequently in any voltage or phase relation desired. The two sets of windings are insulated from each other, and therefore the two voltages are independent.

In operation with zero current output from the alternator, the exciter voltage is the vector sum of that generated by the exciter windings revolving under two sets of field poles. Each alternator field pole is opposite in polarity to its adjacent exciter field pole and displaced approximately 40 electrical degrees in the direction of rotation. There is therefore a differential action of the generated voltage in the extended exciter armature coils as compared to that portion in the exciter armature slots. Any weakening of the alternator field reduces this differential voltage, permitting the exciter voltage to rise somewhat proportionately.

Double armature assembly of 5- and 10-kv-a. full-automatic alternators



Voltage curves of three-phase alternator-exciter unit for various loadings. All curves at running temperatures and with increasing loads; voltage of cold plant about 130

It should be realized that any alternating current in the alternator coils is in synchronism with the respective field magnetism in such a way that the extended exciter armature coils receive their magnetic flux resultant from that of the alternator field poles and the ampere-turns of the alternator coils in the same slots. This change in the relation of voltages generated in the two sections of each exciter armature coil gives the effective compounding desired, and the angular relation of the two sets of field poles decreases this differential or bucking action on low power factors with a corresponding rise in exciter voltage.

To maintain stable exciter voltage over a wide range of alternator loads without extreme magnetic saturation on the heavier loads, the exciter voltage increases approximately 50 per cent on full alternator loads, with a possible 100 per cent rise when starting large polyphase motors. Effective compounding can be altered, if necessary, with an adjustable resistance in the alternator field circuit.

While this system of voltage regulation may serve only small alternators of low voltage, it is machines of this capacity which do not receive technical attention in service. Full-automatic operation necessitates automatic voltage control.

Insulation Research Turns Again to Fundamentals

After digression to follow specific channels of commercial stimulation, insulation and dielectric research is finding that known facts can be interpreted correctly only with fuller knowledge of underlying fundamentals.

AN IMPOSING array of subjects pertaining to the research being directed toward improvements in and a better understanding of electrical insulation was presented at the third annual conference of the Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council. This conference was held at the Bureau of Standards in Washington, D. C., Nov. 7-8, 1930, and attracted the attendance of more than a hundred physicists, chemists, and electrical engineers.

It was of particular significance to note that the trend of research effort in this field is definitely toward a better understanding of fundamentals. This gives rise to hope that the proponents of the three widely held and largely incompatible theories—(1) dipolar molecules, (2) anomalous conduction, (3) colloidal assemblages—may find common ground for an understanding. At the present time none of the theories held really satisfactorily explain the insulation problems faced by the practical electrical engineer.

In an attempt to present something of a cross-section of the activities reflected at the Washington conference the annual report of Doctor J. B. Whitehead, its chairman, is presented herewith practically in full and abstracts of reports of several of the specific studies are presented on the following pages.

◆ ◆ ◆

Year's Efforts Show Commendable Progress

By Dr. John B. Whitehead

The John Hopkins University, Baltimore
Fellow, A. I. E. E.

RESEARCH and development in the field of dielectrics and insulation have resulted in notable progress during the past year. Experimental studies have ranged from fundamental questions in the fields of pure physics and chemistry, through the important intermediate field of effort made to bring together the talents, resources, and enterprise of both pure and applied science to the wide and always active field of direct development by cut-and-try methods for the improvement of insulating materials and structures.

LIQUIDS

In the class of fundamental studies those of perhaps most direct interest are the studies of dielectric constant in liquids, with particular reference to molecular orientation and the contribution of this phenomenon to the resulting polarization. Of special interest is the increasing discussion of polar molecular orientation as an explanation of dielectric loss under alternating stress. Another important group of studies is on the relation between fundamental chemical structure as varied through a series of liquid isomers and their corresponding electric and other physical properties. Several independent researches of this type now are under way. Interest in these two groups of problems is general, not only in this country, but also abroad. More than any others, they give promise of further knowledge of the ultimate structure of the dielectric molecule. Closely related studies are those on the conductivity encountered in commercial insulating liquids and its relation to alternating stress. These liquids often excel in electrical properties, the purest used in physical research and obey much the same laws. In these cases the laws of conductivity are found to vary widely as related to both electric stress and duration of application, both having immediate bearing upon the amount of loss under alternating stress. Several theories have been proposed as to the origin and nature of the several types of ionic carriers apparently present in these phenomena.

CRYSTALS

Important fundamental studies are being directed also to the problems of solids as exemplified in crystals. Their relative freedom from impurities gives favorable opportunity for study of the nature of their residual conductivities, polarization electromotive forces, ultimate electric breakdown strength, and other allied properties. One result of this work has been to show that the structure of even the purest crystals of any considerable size is not so uniform as supposed, and that irregularities and faults often play an important part in the electric behavior of even the best of these materials.

BREAK-DOWN STUDIES

In the intermediate class of studies in which effort is made to combine fundamental knowledge and technique with the problems of practise, there is a remarkably wide range of studies on the breakdown strength of gases, liquids, and solids. Development of the cathode ray oscillograph has extended the range of the intimate observation of short-time phenomena enormously. As a result, in the case of gaseous breakdown, early apparent discrepancies between the results of observation and the indications of Townsend's theory of secondary ionization are now through the recognition of other influences in a fair way of being removed. Chief among these is new evidence as to the importance of space charge resulting from the initial stages of ionization, in setting up new and higher values of local electric stress. The importance of these phenomena in their relation to the shape of discharge electrodes has been recognized with resulting indications for improvement in the breakdown strength of the various flashover gaps of practise.

There have been several series of careful investigations of the conditions surrounding the breakdown of liquids ranging from those of simple type such as hexane, pentane, and xylol, to transformer oil and other commercial insulating liquids. These studies present much new evidence on the influence of temperature, pressure, and shape of electrodes, and particularly of the conductivity as a measure of the dissolved impurities. There is recent evidence that a variation of breakdown voltage with pressure may be entirely attributed to impurities.

Many studies on the breakdown of solids have been reported, mostly from German sources but with one interesting group in this country. Efforts in all this work are directed largely toward a closer control of temperature and field distribution. Results always point to a separation of several possible types of breakdown, notably the simple electric breakdown as based upon molecular structure, and thermal breakdown resulting from temperature increase of conduction in its influence as ionizing agent or directly on molecular breakdown through increased kinetic activity.

CONDUCTIVITY OF INSULATING LIQUIDS

Other studies in the intermediate group referred to are those of the conductivity of insulating liquids with special reference to the modification of their properties through mixtures. An example is an interesting proposal which traces the residual conductivity always found in insulating oils to the presence of colloidal particles always present in such oil. These particles have high powers of absorption which converts them into large, heavy ions. Their action jointly with ions of other types may be invoked for explaining several well-known, but hitherto little understood, peculiarities of liquids of this class. Supporting the suggestions of several speculative studies in this field, the presence of space charges in liquids also has been shown with associated variations of potential gradient. In accordance with indications of this type, it would appear that all liquid insulators, even the best, have a small residual conductivity due either to dissociation or to extraneous radioactive influence, but that this conductivity has relatively little influence upon their behavior as insulators. More important is a superposed conductivity due either to residual impurities or perhaps to partial molecular instability, which results in a larger and heavier type of ion that plays its part in the formation of space charges and particularly in the short-time conductivity which reflects itself in dielectric loss.

Another group of studies of liquids are those directed toward the stability of the ultimate structure as revealed under the influence of corona discharges, high stress, cathode ray bombardment, and the like. The gases involved and the residual products are looked to for indications of the nature of the deterioration process in insulating oils.

HIGH-TENSION LINES AND CABLES

Also covering an extension range, the third broad group of development studies involves direct experiments on the improvement of known insulating materials and methods, and the discovery of new ones. Improvement of insulation for overhead high-voltage lines heretofore has not engaged the attention of the National Research Council's committee on electrical insulation; nevertheless it is an active field from the standpoint of insulation and there is a continued study by its own group of specialists. In this direction conspicuous results have been obtained recently in increased knowledge as to the importance of the mechanical design of terminals and flash-over distances in their influence upon the distribution of electric stress and breakdown voltage. Here, progress is directly related to the more fundamental work on the breakdown of gases already discussed.

Problems presented in impregnated paper as applied to high-voltage underground cables comprise another extremely active field. Studies in this field range from the original structure, manufacture, and resulting properties of paper, through a broad series of problems in impregnating oils, into the methods of impregnation and assembly. Another group concerns itself with modifications of the mechanical setup of the cable structure itself—all looking to higher stresses and longer life. Among the more important accomplishments are increased knowledge as to the stability of oils, the separation of the component losses in impregnated paper, better understanding of internal ionization, and many others.

Several investigations—usually accelerated life tests

—as to the influence of residual air and residual moisture in cable insulation are under way. In this connection, problems demanding solution include a suitable accelerated life test on small samples and the law connecting life with voltage and time. Less attention apparently has been given to the question of wax formation in cables, which still remains unexplained. Many improvements in both electrical and mechanical characteristics of various materials for relatively low-voltage insulation have been announced. Noteworthy reports have been made of non-lead-covered insulation for underground service and of rubber insulation having corona-resisting properties.

Increasing evidence of the advantages of oil-filled cable must be given conspicuous mention. Originally developed for the highest voltages, its value in lower ranges now is recognized largely because of the simplification of joints, terminals, oil-feed, impregnation, and other features.

Reference to all this progress would not be complete without mention of the agencies in this country responsible for it. Universities, government agencies, national scientific bodies, manufacturers and public utilities are all uniting in the attack. Each fitted for special types of investigation, their joint efforts insure a steady advance in knowledge.

REFERENCES TO CURRENT LITERATURE

For the convenience of those who may wish to view first-hand the contemporary published record of information that has come to the attention of Doctor Whitehead during the past year, and upon which some of his conclusions are based, the following list is given:

Bibliography

Minimum Breakdown Field Strength for Spherical Electrodes, by S. Franck, *Archiv f. Elektrotech.*, XXIII, 2, 1929, p. 226.

The Development of the High-Voltage Electrostatic Voltmeter, by A. Imhof, *Archiv f. Elektrotech.*, XXIII, 2, 1929, p. 258.

Breakdown of Liquid Insulators, by L. Inge and A. Walther, *Archiv f. Elektrotech.*, XXIII, 3, 1930, p. 279.

The Breakdown Strength of a Few Solid Insulating Materials under Long-Time and for Short-Time Stresses, by R. Jost, *Archiv f. Elektrotech.*, XXIII, 3, 1930, p. 305.

The Electric Breakdown of Air Between Concentric Cylinders, by E. Uhlmann, *Archiv f. Elektrotech.*, XXIII, 3, 1930, p. 323.

The Dielectric Properties of Low-Voltage Impregnated Paper Condensers, by F. A. Schafer, *Archiv f. Elektrotech.*, XXIII, 3, 1930, p. 351.

Studies of the Dielectric Strength of Solid Insulators, by K. Meyer, *Archiv f. Elektrotech.*, XXIV, 2, 1930, p. 151.

Studies on the Influence of Heat on the Breakdown of Solid Insulators, by K. Moerder, *Archiv f. Elektrotech.*, 24, 2, 1930, p. 174.

Positive Ions of High Ionizing Power and Their Influence on the Electric Breakdown in Air, by O. Mayr, *Archiv f. Elektrotech.*, XXIV, 1, 1930, p. 8.

Voltages Steps in Spark Discharge, by O. Mayr, *Archiv f. Elektrotech.*, XXIV, 1, 1930, p. 15.

The Influence of Pressure on the Breakdown Voltage of Liquid Dielectrics, by H. Edler, *Archiv f. Elektrotech.*, XXIV, 1, 1930, p. 37.

The Electric Breakdown of Air in Non-Homogenous Fields, by E. Marx, *Archiv f. Elektrotech.*, XXIV, 1, 1930, p. 61.

Oscillographs of the Currents in Insulating Materials, by A. Gemant, *Archiv f. Elektrotech.*, XXIII, 6, 1930, p. 683.

The Relation Between the Electric Losses and the Viscosity of Impregnating Materials, by E. Kirch and W. Riebel, *Archiv f. Elektrotech.*, XXIV, 3, 1930, p. 353.

Space Charges and Space Forces in Insulating Materials, by P Boning, *Zeitsch. fur Tech. Physik*, IX, 1930, p. 373.

A New Point of View for the Determination of the Quality of High-Voltage Lead Covered Cables, by Walter Schmidt, *Rev. Gen. Elec.*, XXVIII, 4, July 26, 1930, p. 127.

The Problem of Insulating Oils, by H. Weiss and T. Salomon, *Rev. Gen. Elec.*, XXVIII, July 12, 1930, p. 61.

The Impregnation of Insulating Materials, by M. Michailo, *Elektrotech. Zeitsch.*, XXXIII, August 14, 1930, p. 1158.

Dependence of the Resistance of Insulating and Other Materials on the Voltage and Frequency, by P. Boning, *Zeitsch f. Tech. Physik*, III, 1929, p. 82.

Dependence of the Resistance of Insulation and Other Materials on Voltage and Frequency, by P. Boning, *Zeitsch. f. Tech. Physik*, IV, 1929, p. 108.

Static Electrification and Electric Conduction of Hydrocarbon Liquids, by L. Bruninghaus, *Rev. Gen. Elec.*, XXIII, 30, November 1929.

Dielectric Loss and Breakdown in Porous Insulating Materials, by A. Gyemant, *Zeitsch f. Tech. Physik*, X, 8, 1929, p. 328.

The Dependence of Polarization E. M. F. and True Conductivity of Crystals on the Field Strength, by O. Beran and F. Quittner, *Zeitsch. f. Tech. Physik*, LXIV, 11 and 12, 1930, p. 760 (done in Smekal's Laboratory).

Dielectric Polarization in Liquid Mixtures, by N. N. Pal, *Phil. Mag.*, X, 63, 1930, p. 265.

Organic Reactions in Gaseous Electrical Discharge I—Normal Paraffin Hydrocarbons, by E. Linder, *Phys. Rev.*, 36, No. 8, 1930, p. 1375.

Phase Defect Angle of an Air Capacitor, by W. B. Kouwenhoven and C. L. Lemmon, A. I. E. E. Trans., 49, July 1930, p. 952.

Some Problems in Dielectric Loss Measurements, by C. L. Dawes, P. L. Hoover and R. H. Reichard, A. I. E. E. Trans., 48. October 1929, p. 1271.

Guarding and Shielding for Dielectric Loss, Measurements on Short Lengths of High-Tension Power Cables, by E. H. Salter, A. I. E. E. Trans., 48, October, 1920, p. 1294.

The Conductivity of Insulating Oils, by J. B. Whitehead and R. H. Marvin, A. I. E. E. Trans., 49, April 1930, p. 647.

Behavior of Dielectrics, by R. R. Benedict, A. I. E. E. Trans., 49, April 1930, p. 739.

Three Regions of Dielectric Breakdown, by P. H. Moon and A. S. Norcross, A. I. E. E. Trans., 49, April 1930, p. 755.

Ionization Studies in Paper Insulated Cables III, by C. L. Dawes and P. H. Humphries, A. I. E. E. Trans., 49, April 1930, p. 766.

Development of Insulating Oils, by C. E. Skinner, A. I. E. E. Trans., 49, January 1930, p. 35.

Ionization Currents and the Breakdown of Insulation, by J. J. Torok and F. D. Fielder, A. I. E. E. Trans., 49, January 1930, p. 352.

Dielectric Absorption and Dielectric Loss, by J. B. Whitehead, *Frank. Inst. Jl.*, 208, No. 4, October 1929.

◆ ◆ ◆

Conductivity of Insulating Oils

PAPERS by Doctor J. B. Whitehead and by Prof. K. F. Herzfeld present further results from the extended program of research under way at Johns Hopkins University on the fundamental properties of insulating liquids, with special reference to their use for the impregnation of paper. The general course of these studies has indicated that within the normal operating range of temperature the dielectric loss in insulating oils of the better known types can be entirely accounted for by the conductivity as measured for the very short time intervals corresponding to the period of commercial alternating circuits. In the case of impregnated paper, dielectric loss is entirely accounted for by dielectric absorption as measured under continuous potential. Doctor Whitehead's paper is a further study of the short time conductivities, and has revealed for the first time the presence of dielectric absorption in a liquid. The influence of this on dielectric loss is examined. His own abstract follows:

"Continuous-current characteristics of several insulating oils are studied for time intervals beginning 0.001 sec. after the application of voltage or short circuit. Essential equipment is the amplifier oscillograph in connection with a quick-acting switch. It is found that in one group of oils there is an initial conductivity which is constant over the period of the first second following the application of the voltage. Thereafter there is a slow decrease of conductivity to a final value much lower than the initial value. It is shown that this initial constant conductivity is sufficient to account for all of the dielectric loss under alternating stress.

"In another group of more carefully refined and deaerated oils there is superposed upon the brief initial constant conductivity a still shorter initial evidence of dielectric absorption. During the first few thousandths of a second the charging current decreases sharply; is followed thereafter by a constant conductivity up to about one second, and thereafter decreases further to a much lower value after a long time. The initial absorption period has a corresponding discharge curve on short circuit. The measured value of the alternating loss in this case is completely accounted for by the sum of the loss due to the initial period of absorption in combination with the succeeding short-time-constant conductivity.

"Other results are presented on the variations of the initial and final conductivities with the voltage and with temperature. The final currents show saturation characteristics, but the initial high conductivities do not."

In Professor Herzfeld's paper are given results of a mathematical study of Prof. Whitehead's results, looking to a determination of the size and character of the ions involved in the anomalous conductivity of these oils. This question has direct bearing upon the problem of the change in electrical behavior and characteristics of impregnated paper as related to those of its two constituents. Studies of this question also were described in a separate paper, presented at the same meeting by Doctor W. B. Kouwenhoven. Prof. Herzfeld's abstract follows:

"It has been shown in a previous paper how the methods developed in the study of conduction of electricity through gases could be applied to determine the nature of the ions present in liquids and solids. In the present paper these methods have been applied to the measurements (recently performed by Whitehead and Marvin) of the space charge set up in insulating oils by a steady electric field. The procedure is the following:

"The shape of the curve shows that the current must be considerably below three-fourths of the saturation current. It is possible to fit the curve closely by assuming the Langevin constant to be $\beta = 36 \pm 10$. From this the number of ions present in the normal state and their mobility can be calculated, which turns out to be $3.5\ 10^{-6} \pm 50\% \ \frac{\text{cm.}}{\text{sec.}}$ per $\frac{\text{volt}}{\text{cm.}}$. With that assumption the mobility is of these ions inversely proportional to the viscosity; mobility in water would be $1.2\ 10^{-4} \frac{\text{cm.}}{\text{sec.}}$ per $\frac{\text{volt}}{\text{cm.}}$ or, in the usual units, 12. If one assumes that Lorenz's results for organic ions can be applied, these ions should have approximately 110 atoms. From the boiling point of the oil one would conclude that the molecule of the oils contains about 45 atoms."

◆ ◆ ◆

Impregnated Paper Insulation

By F. Hamburger, Jr.

Johns Hopkins University, Baltimore
Associate, A. I. E. E.

THIS abstract of a preliminary report gives some results of a study of the life of impregnated paper insulation under way at the School of Engineering, Johns Hopkins University. The work is being supported by the subcommittee on impregnated paper-insulated cable research of the National Electric Light Association. In an earlier work under the same auspices, a study was made of the influence of residual air on dry impregnated-paper insulation. Results of that study (Vol. 47, No. 1 TRANSACTIONS A. I. E. E., January, 1928) showed the desirability of investigating the effect which different amounts of residual air would have upon the life of impregnated paper insulation. A brief summary of the results so far obtained is given here in the form of eight conclusions, briefly qualified.

LIFE-PRESSURE RELATIONS

A series of accelerated life tests were made on more than 135 samples of impregnated paper insulation in which the only variable was the amount of residual air. Results of this extensive series of tests led to the following conclusions:

1. The life of impregnated paper insulation increases steadily with a decrease in the amount of residual air.
2. The life of impregnated paper insulation decreases rapidly impregnation pressures above 2.5 cm. Hg., absolute pressure.
3. For pressures below 2.5 cm. the normal variations in structure of the samples, particularly tightness, are more important than the amount of residual air.

The pressure range from 40 cm. to 2.5 cm. studied with one compound showed an increase in life from 150 to 2,370 hr. A second compound was used to investigate the pressure range from 2.5 cm. to 2 mm. and in that region the decrease in pressure was accompanied by an increase in life from 4,159 to 6,370 hr. In addition to these conclusions as a direct result of the tests, the necessary preliminary work led to the development of a satisfactory type of sample and reenforced ends for use in accelerated life tests. Several other interesting features have come out of the work which will be treated briefly here.

VOLTAGE-TIME RELATIONS

Accelerated life tests were carried out by means of a step-test in which several different voltages were used. A typical example of the step method used on a number of samples is as follows:

400 Volts per mil for 22 hr.
500 Volts per mil for 22 hr.
600 Volts per mil for 112 hr.
700 Volts per mil to breakdown

Since the step-test was used it was necessary to have some method of correlating the lives of the samples at the different gradients of the test. Investigation led to the adoption of the so-called "eight-power law" as a mode of comparison. From the experience obtained in this connection the following conclusion was reached.

4. The so-called "eight power law" is sufficient for making correlations in such tests as these but leads to unreasonable results if an attempt is made to use it to predict actual life from accelerated tests.

CABLE COMPOUND DETERIORATION

Of the two cable compounds used the first supply was put up in five-gallon cans sealed under vacuum at the refinery. Some of this compound was not used until after it had stood in the containers for seven or eight months; when it was used a marked deterioration was found to have occurred. The second shipment was supplied in 50-gallon drums and was protected from air by the presence of carbon dioxide. Over a period of nine months this compound showed no deterioration. Hence, the conclusion reached is:

5. Cable compound deteriorates even if it contains only a small amount of air, in spite of its being kept in sealed containers. Air should be entirely excluded to avoid deterioration.

POWER FACTOR CHARACTERISTICS

Power-factor characteristics were followed carefully throughout the life-test work; such observations have led to the conclusion:

6. Power-factor characteristics such as the variation of power factor with respect to voltage, power-factor variation with respect to time, or the absolute value of power factor give no indication of insulation life.

PREDETERMINATION OF INSULATION LIFE

The first period of voltage application during the life test, usually 22 hours at 400 volts per mil, was accompanied in almost every case by an increase of power factor. This initial power-factor rise seems to bear some relation to the life of the insulation and leads to a fair correlation which seems to be worthy of calling to the attention of workers in the insulation field. The conclusion drawn is:

7. Power-factor rise due to the initial application of voltage during a life test may be a criterion of insulation life.

This point seems worthy of further study.

◆ ◆ ◆

Predetermination of Cable Deterioration

IN abstracting his report "The Predetermination of the Deterioration of Impregnated Paper Insulation," D. W. Roper, Commonwealth Edison Company, Chicago, says:

"All specifications for impregnated-paper-insulated, high-voltage cables, both domestic and foreign, are defective in one respect; namely, they do not insure the stability of the insulation under normal working conditions. Several suggestions have been made in this country and abroad, and the Commonwealth Edison Company has tried all of these tests on samples of 66-kv. single-conductor commercial cable made in the past few years, and it has also tried a few new methods of its own devising.

"While these tests, which have continued over a period of more than two years, have resulted in securing some interesting technical and scientific information, up to the present time they have not discovered any test which could be made within the span of few days, and yet be sufficiently accurate to be included in cable specifications as a test for stability of the insulation."

◆ ◆ ◆

Chemical Research in the Field of Dielectrics

CHEMISTRY is playing an ever-increasing part in insulation practise. F. M. Clark, General Electric Company, Schenectady, chairman of the subcommittee on chemistry, in abstracting his report, says:

"During the year 1929-1930 there has been unusual activity as reported in the journals covering the chemistry of insulating materials. While major interest has centered in molecular phenomena, the chemistry of insulation testing and the development of new materials has not been neglected. There has developed both in this country and abroad a decided tendency toward the gaging of insulating materials on the basis of chemical aging rather than placing principal reliance on the initial characteristics. This demands improved testing methods. The determination of acidity in both paper and oil by electrometric rather than by colorometric analysis has given the insulation engineers a more satisfactory tool.

"The problem of rating mineral oils for transformer use is still unsolved. Sludge accumulation tests slowly are displacing the older tests based on the formation of first traces of sludge. No decision for or against oxidadation under voltage has been made. Studies in the dielectric behaviour of organic liquids such as oil under varying types of electric discharge or under varied conditions for dielectric strength and the relation of these properties to the chemical nature of the material tested should go far in determining the characteristics and the development of new types of liquid dielectrics. The type of discharge has been found to have but little effect on the products formed from the vapors of hydrocarbons, alcohols and organic chlorides. Recent work on the importance of impurities in oil has confirmed the older research results.

"Continued researches during the year have substantiated the hysteresis phenomenon noted in the water sorption curve for paper. The desorption moisture contents are higher than the absorption, due, it is believed, to changes in micellar surfaces of the cellulose. The adsorbed water molecules are held by residual valences. In cotton, the hydroxyl of the cellulose holds adsorbed water. Acetylation of the cotton therefore should result in decreased water adsorption, a prediction in accordance with experiments.

"That the breakdown of solid dielectrics is fundamentally electrolytic in nature is gaining considerable recognition. Whether electric breakdown is thermal or an ionization effect depends according to the newer ideas on the conditions of test. Secondary chemical changes in the dielectric itself or the testing medium may be of major importance in determining dielectric failure.

"Continued study of molecular phenomena during the year has given added confirmation to Debye's theory. Deviations in most cases have been due to the effect of neighboring molecules. Pronounced polarity is doubtless a factor in chemical behaviour, but a large portion of the polarities, assigned by various electron theories of valence, must not be considered as a physical fact but rather as a pragmatic representation of chemical behaviour.

"Careful study of the dielectric constant of organic materials is being pursued to determine changes in both chemical and physical properties. Crystalline formation in inorganic oxides has been shown to produce a drop in dielectric constant. Changes in the dielectric constant of amorphous substances have been approved to indicate crystalline formation. With the recognition of such changes, the synthesis of materials especially designed for the purpose may well be expected as the next step."

A bibliography listing 68 references to current material concerned with the chemical side of insulation research was presented as part of the report of which this is an abstract. Mimeographed copies of that bibliography may be obtained upon application to the Editorial Department, Electrical Engineering, 33 West 39th St., New York, N. Y.

◆ ◆ ◆

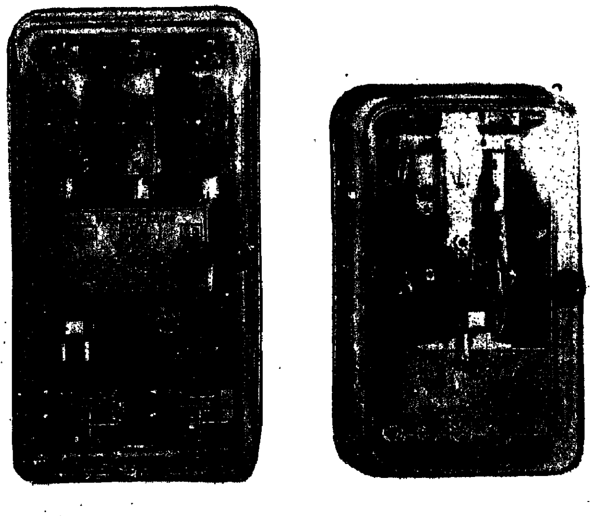
Relays to Operate in One-Sixtieth Second

A WHOLE new family of quick-thinking, fast-acting relays which operate in a single cycle, and base their decisions not on the customary time elements, but upon comparison of instantaneous values has appeared this year. Together with high-speed circuit breakers, they represent the modern view that continuity of service is best assured by cutting off troubles as fast as possible. All these Westinghouse relays act in one-sixtieth of a second—three to ten times as fast as has been customary.

The *HZ* relay on the left of the illustration, in case of trouble on long transmission lines by means of a little wattmeter element perceives within one cycle which way the fault current is flowing, and estimates the distance to the fault by balancing this current against the voltage drop from the station to the short circuit, thus measuring the impedance.

Transformers or other connected apparatus which develop internal disorders are removed from the system by the *HA* differential relay without the rest of the system being disturbed by the opening of other relays.

High-voltage systems are frequently annoyed by grounds, and this is the specialty of a third high-speed relay; it operates on a comparison between the relative direction of residual line current and current in the



These relays operate in a "split second" grounded neutral of power transformers and is both extremely simple and fast.

Parallel transmission lines have an understanding friend in the *HD* relay at the right. It not only sectionalizes the proper line in the twinkling of an eye, but thoughtfully doubles the tripping value of the line left in service. It operates upon a comparison of the sum and difference of currents in the two lines.

◆ ◆ ◆

Tennessee Lightning Investigation Continues

Test results indicate that only one conductor of a line is involved in any one direct stroke; often is one adjacent to approaching storm.

By J. Elmer Housley

Knoxville Power Company,
Alcoa, Tenn.
Associate A. I. E. E.

WITH the general acceptance of the cathode ray oscillograph in 1928 for field investigations of lightning, a cooperative research was undertaken jointly by the Knoxville Power Company and the Westinghouse Company, for which two field laboratories were established near Alcoa, Tenn. The factors governing the selection of this location were the great number of thunder storms and the existence there of a heavily-insulated tower transmission line with two circuits, operating at 150,000 volts. The profile of the line varies from 700 ft. to 2600 ft., following a rugged country with several long river crossings.

The configuration of the cables is vertical on the double-circuit towers with the middle wire 4.5 ft. toward the tower and a vertical separation of about 12 ft. between wires. The single-circuit lines have a horizontal configuration with 17.5-ft. spacing.

The suspension insulators are composed of 10 disks, and the dead-end assembly of each of the triple strings have 12 disks. Horn-gaps are used on the line and ground side and a horn is placed on each side of the insulator string over the axis of the cable in suspension units, and above the insulator in horizontal strings. A half-inch steel ground wire is common to both types of towers.

Cathode-ray oscillograph and related equipment in field laboratory

The stations were located near tower 70 and tower 93 respectively, but the former was too remote from the storms at the ridge of the mountain and will therefore be discontinued.

Three klydonograph installations were established in conjunction with each station. All klydonograph potentiometers were of the three-phase type, one was located adjacent to each station and one on either side of the stations one mile distant. This is illustrated below. The klydonographs are equipped with eight-day clocks and the film records are removed weekly.

The station at tower 70 is a frame building lined with heavy grounded wire screen, and at tower 93 is a sectional steel building grounded at several points.

The equipment in each station is identical. A gasoline-driven 15-kv-a., 110-volt, three-phase, 60-cycle, a-c. generator supplies power for station use. The direct-connected 1-kw. exciter furnishes 125-volt direct current for use in the concentration coils on the oscillograph.

The Norinder oscillograph with its axuiliary equipment, consisting of vacuum pump, switchboard, linear timing device, oscillator and high-voltage rectifier has been used throughout the tests and many improvements have been made in the apparatus and increased reliability has been obtained.

Three-phase potentiometer and Klydonograph installation for lightning studies

---

From "Lightning Investigation at Alcoa, Tenn.," presented at A. I. E. E. Southern District Meeting, Louisville, Ky., Nov. 19-22, 1930.

The small number of oscillograms obtained since the stations went into operation do not give a complete picture which would enable an analysis to be made of the waves appearing on the line with their exact point of origin and probable voltages which existed there. The data obtained and observations made during the past three years have been valuable in relation to the development of the cathode ray oscillograph and demonstrated the importance of this device in the field.

Since the location of storms must be very close to the station, chance plays a large part in the volume of data obtained. Accordingly it is hoped that by continuing the investigation over a period of time that a sufficient number of surges will be recorded so that a complete analysis of them may be made. Low-resistance tower footings and ground wire were indicated as desirable for decreasing flashovers.

◆ ◆ ◆

Lighting Airway Beacons

High-tension transmission lines may be tapped directly, through the use of a capacitor potentiometer device to supply as much as 3 kw. of electric energy for isolated airway stations.

By F. W. Cartland

Capacitor Engineer,
Westinghouse Electric & Manufacturing Company
Associate A. I. E. E.

RAPID PROGRESS of aviation during the last few years has emphasized the need of adequately lighted airways. Airports have been located near the cities where electric power for floodlights and searchlights was readily available, but the supply of power to airway beacons in isolated places has been a more difficult problem. Beacons in such localities have been operated from low-voltage transmission lines or where these were not available, gas engine-driven generators have been used. The power required for such installations is approximately 2 kw., and low-capacity transformers are available where the system voltage does not exceed 23,000 volts. When higher voltage lines are encountered the smallest standard transformers built vary from 15- to 100-kv-a., increasing with the system voltage. A 100-kv-a. transformer used to deliver only 2 kw. is not only expensive but also inefficient.

A paper presented by Messrs. Spracklen, Marshall, and Langguth at the Winter Convention, February 13-17, 1928, described a potentiometer device for use with condenser type bushings, which supplied sufficient power for operating relays and synchronizing equipment. With the development of high-voltage outdoor capacitors of the suspension type, came the possibility of adapting them to a potentiometer circuit which would supply greater amounts of power than obtained from a condenser bushing. While the capacitor could be thus used to supply very great quantities of low-voltage power, the capacitors as built at present are of such size and construction that it is not considered desirable or economical to obtain more than 2 or 3 kw. from such a circuit.

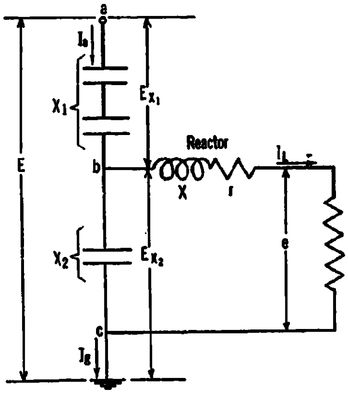


Fig. 1. Theoretical circuit, single line to ground

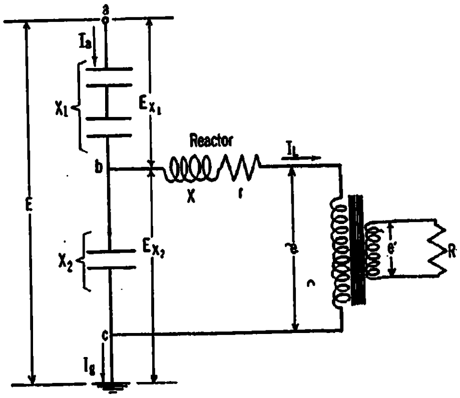


Fig. 2. Single line to ground using small transformer

The capacitor power supply or "capacitap," consists essentially of a number of suspension type capacitors connected in series with a portion paralleled by the load and a reactor in series (Fig. 1). Since in most cases voltage at the load is 110, considering capacitor economy, the use of a small transformer (11,000/110) as shown in Fig. 2 is more desirable. Considering circuits which produce the same voltage regulation, another

---

From "Lighting Airway Beacons" presented at the A. I. E. E. Southern District Meeting, Louisville, Ky., Nov. 19-22, 1930.

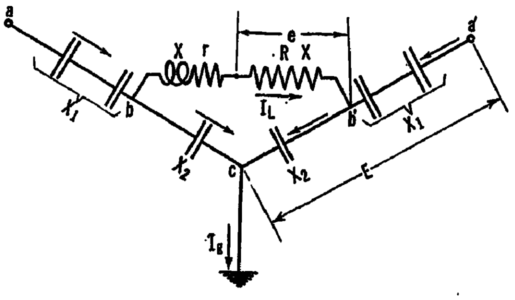
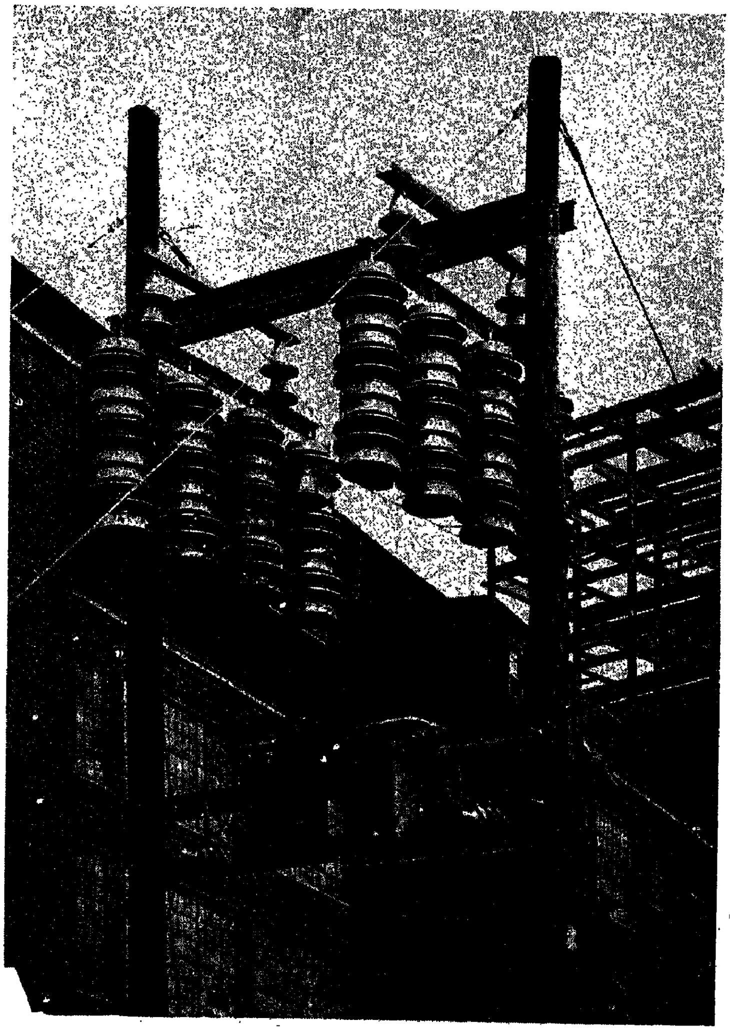


Fig. 3. Theoretical circuit, double line to ground

modification of this circuit, as shown in Fig. 3, has an additional advantage in that the full-load ground current is much less than that of the equipment shown in Fig. 2.

A capacitap as shown in Fig. 4 was built for studying the performance and practicability of this circuit. The equipment, built for supplying 2½-kw. unity power factor at 110 volts from a 66-kv. line, had load voltage curves as shown in Fig. 5. The curve of Fig. 6 shows the result of varying the size of reactor. The complete circuit as shown in Fig. 7, consisted of eight low-voltage capacitors, sixteen high-voltage capacitors shown in Fig. 8, a standard transformer, a reactor and two enclosed spark-gaps. Both transformer and reactor were tapped to give the desired adjustments. Each of the low-voltage capacitors was 0.020-μf., 10,000-volt and each of the high-voltage capacitors was 0.008-μf., 16,000-volt. The reactor was designed for 14,000 volts and had 176 henrys maximum inductance. The spark-gaps were placed in parallel with capacitors *b c* and *b' c*.



Close-up of an experimental pole-top on taking 2½ kw. from a 66-kv. line

The individual capacitor unit is shown in Fig. 8. It is similar in design to those used for carrier current applications, but has a special rating. The construction is such that the capacitor will flash over the outside of the porcelain before it will flash through the inside; the characteristics are similar to those for line insulators; the wet flashover at 60 cycles is 70-kv. and the dry flashover is 116-kv. The weight of each capacitor is approximately 115 lb.

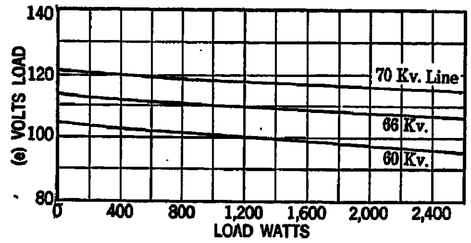


Fig. 5. Load-voltage curves taken from an experimental installation

INSTALLATION

The capacitap may be installed in several ways; by suspending from an existing tower, or from a tower or pole erected especially for carrying this load. The weight of the complete equipment shown in Fig. 4 is about 3000 lb. Although the equipment may be connected directly to the transmission line, the operating companies will probably use disconnecting switches. As this type of equipment may be mounted in suspension, it will be unnecessary to build an enclosing fence as required for equipment mounted on the ground.

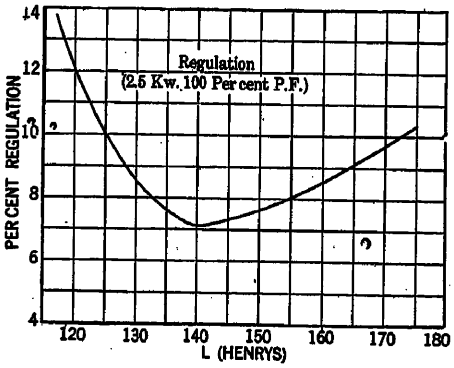


Fig. 6. Curve of regulation vs. inductance of reactor

A study of the various possible circuits has definitely shown that the capacitap may be well adapted to certain classes of loads, while for others the operation would be highly unsatisfactory. For example, either the supply of power to a beacon lamp load or the supply for charging a storage battery through a rectifier would be a satisfactory load; however, the operation of a large motor, or the closing of a circuit breaker would not be suitable. A current surge as encountered in starting a motor should not be delivered by the capacitor power supply as at present designed. Reference to Fig. 9 will show that as the load current increases, the voltage in various parts of the circuit rises, and in all places the maximum voltage must not exceed the rating for which each part is planned. The reactor used in the equipment built for study was designed for 14,000 volts; it will be seen, therefore, from curves of Fig. 9 that the load must not exceed 2700 watts. Also, an overload will cause a current which may saturate the reactor, a condition which would tend to limit the voltage rise on the capacitor. The spark-gaps were installed to protect the circuit from excessive voltage rises.

The capacitap and the transformer both supply low-voltage power from a high-voltage line and there are many things to be considered when choosing between them for any particular application. In general, where less than 3 kw. are required, the transformer will be better adapted to the lower-voltage systems, whereas the capacitap is better adapted to the higher-voltage systems. The dividing line between a high-voltage and a low-voltage system is rather indefinite and will depend somewhat upon the applications. For example, the supply of 2 kw. from a 44,000-volt line (25,400 volts to ground) will be best obtained from a transformer, while the supply of 100 watts at 110 volts for charging a storage battery (through a rectifier) may be economically obtained with the capacitap. For all ratings, the efficiency of the transformers and capacitaps is very high at full load, whereas a 50-kv-a. transformer (high voltage) used to supply 2 kw. will be much less efficient.

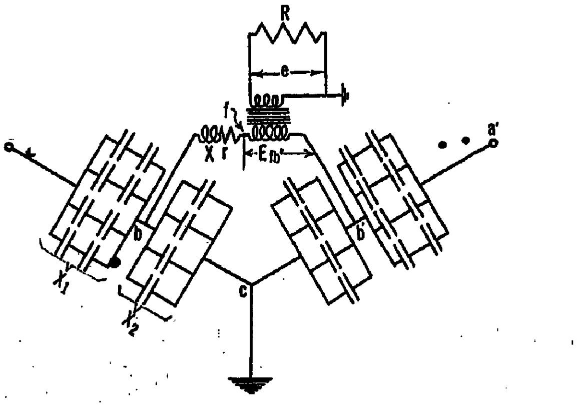


Fig. 7. Complete circuit of equipment shown in Fig. 4

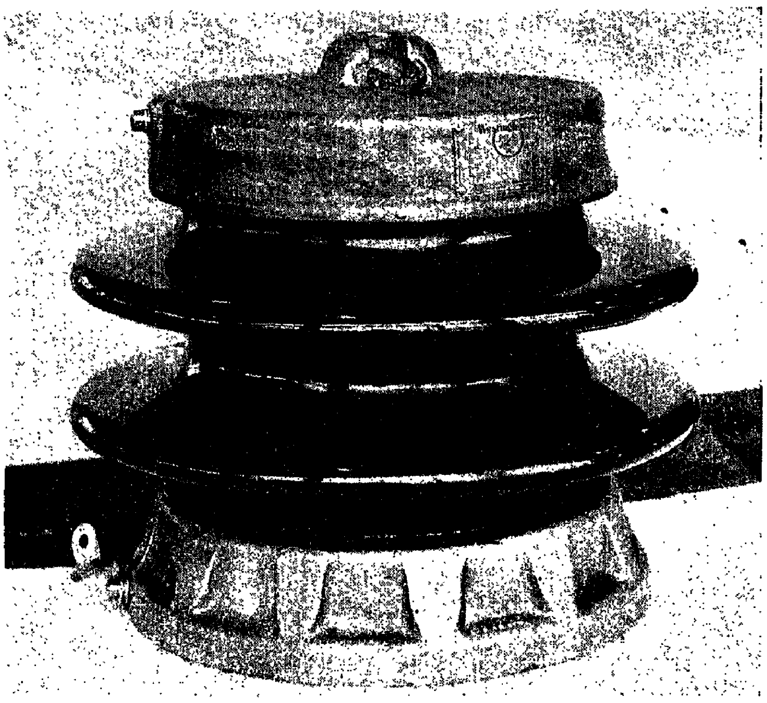


Fig. 8. Single suspension capacitor unit

There are so many variable factors in the design of a capacitap that all study has been limited to a grounded-neutral system; other arrangements adaptable to ungrounded or delta-connected systems will likely follow.

Single-phase power may be obtained from the use of a line-to-ground connection, (Fig. 2) or a double line-to-ground connection, (Fig. 7). Often one may be considered as a substitute for the other, although the inherent characteristics of each will greatly affect the choice. As will be shown later, the double line-to-ground circuit has a ground current which is constant and independent of load; however, the single line-to-ground circuit has a ground current which increases with load. If the ground current should become an important factor—especially in the vicinity of telephone circuits—it would be necessary to consider the use of the double line-to-ground circuit instead of the single line-to-ground circuit.

Another factor which should always be considered is voltage regulation; the nicer the regulation required, the larger and more expensive the equipment will become. The regulation is a function of the total kv-a. of capacitors and the ratio between the impedance of the line and ground branches of the circuit. The single line-to-ground circuit will be found to have slightly better regulation than the double line-to-ground circuit, using the same capacitors in either circuit.

The capacitor power supply (capacitap) is an assembly of capacitors and associated apparatus which supplies power at a reduced voltage from high-voltage lines. The present practical limit is from 3 to 5 kw. Tests have shown that such an equipment has characteristics which are suitable for certain types of loads only—such as airway beacons. The capacitors are very reliable, and being designed for suspension above the ground, with an enclosing fence unnecessary, the factor of safety is large. Two single-phase circuits are possible each having different characteristics with regard to ground current and voltage regulation. Only applications of the capacitap to grounded neutral systems have been considered; it is especially adapted to high-voltage systems.

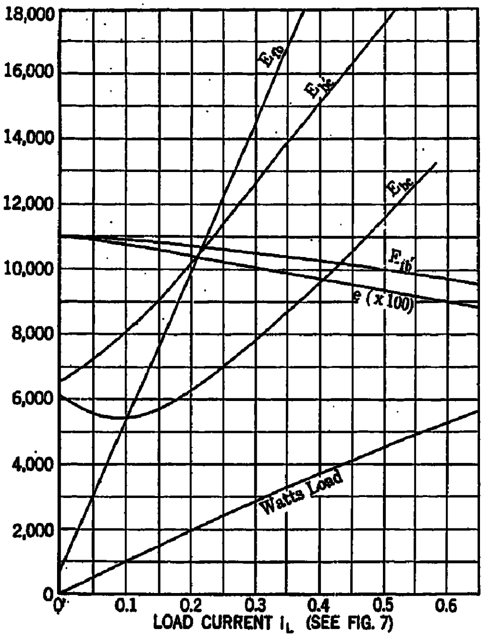


Fig. 9. Load and voltage characteristics

The condenser bushing potential device as developed by J. F. Peters supplied the basis for development of the capacitor power supply, and the author wishes to acknowledge with thanks, Mr. Peters cooperation in the present development.

◆ ◆ ◆

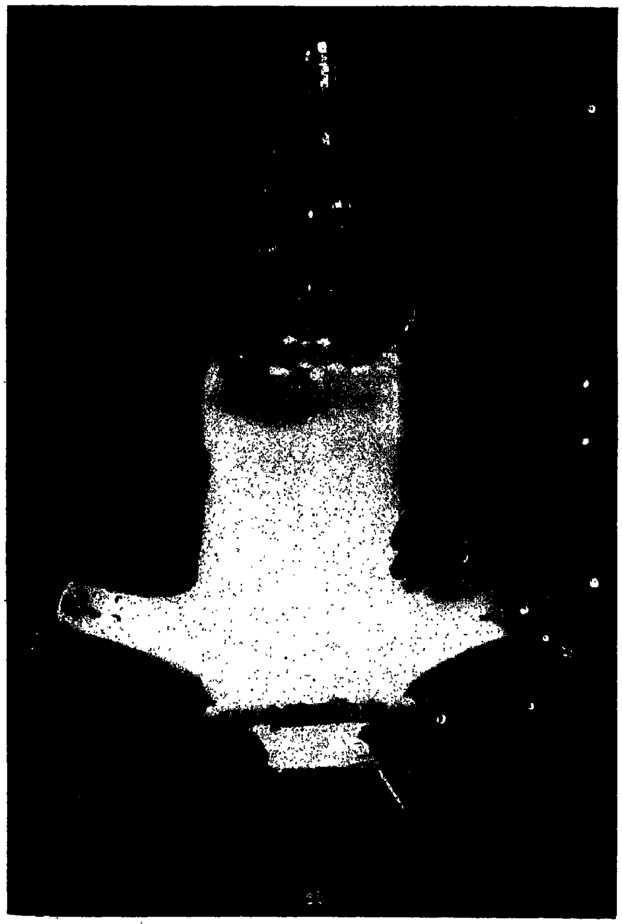
Vacuum Tubes Lead the Way

OF all the possibilities which beckon the scientist outside the narrow range of pressure and temperature in which we live, none has shown more alluring results than the family of vacuum or low-gas-pressure tubes. Incandescent lamps, X-rays, mercury rectifiers, radio tubes, photoelectric devices, and hyper-sensitive relays are among the substantial things which have already been summoned forth from the nothingness left by the vacuum pump. Other very practical developments are following; nowadays tangible results follow close upon the heels of theory.

A mercury grid-glow tube under development at the Westinghouse research laboratory, but not yet commercially available, can break 165 kw. (300 amperes, 550 volts) as often as desired, up to even a hundred times a second, with no burning of contacts. The control circuit of this contactor (for such it is in effect) takes so little current it cannot be measured.

This grid-controlled mercury switch is a lineal descendant of the little grid-glow tube which D. D. Knowles invented four years ago. It is in fact a grid-glow tube in which the cathode is a hot mercury pool. It looks like the mercury vapor rectifier to which it is akin; and like it, is started by tilting. The anode, however, at the top of the tube, is totally enclosed by fine nickel gauze (nickel, because it does not amalgamate with mercury). From this anode current flows to the mercury pool at the bottom, the two horizontal electrodes performing the "keep alive" function. A life of several thousand hours is expected. The efficiency is very high—about 99.9 per cent.

The importance of the device is more easily seen by viewing it not for its structure, as a sort of tube, but by its function, as a high-speed, arcless contactor, able to handle substantial amounts of current at any voltage up to several thousand with but a few micro-amperes in the control circuit—a contactor involving no wear of mechanical parts or maintenance, throughout its life.



A grid-glow tube that can interrupt 165 kw.

It already has been used to operate and control motors as large as 10 hp., and with an additional tube, was able also to serve for voltage control.

Some Aspects of

Federal Regulation of Water Power Development

Amazing advance in the use of electric energy during the past decade focuses attention upon the part played by the Federal Government in power development and production. Interesting facts are reviewed here.

By Frank E. Bonner

Executive Secretary
Federal Power Commission
Washington, D. C.

THE PREEMINENT position that has been attained by the United States in the utilization of electrical energy for turning the wheels of industry and lightening the labor burden of homes and farms, makes it of some interest to consider what assistance or encouragement the Government may have contributed toward this result. The primary relation of this industry is with the states, but with the growth of system interconnection, some problems of an interstate nature are beginning to arise. Proposals for their solution through imposition of Federal activity contemplate a minimum of interference with the existing machinery of the state agencies.

It is evident that the contacts of the Federal Government with the manufacturers and distributers of electrical energy have been confined mostly to those which are common to all industries. One prominent exception is in connection with the development of water power. Here through a combination of the Federal responsibility for navigation and the ownership of public land, the Government finds itself a shareholder in many potential water-power sites.

U. S. GOVERNMENT IS LARGEST REAL-ESTATE HOLDER

The fact sometimes is overlooked that the Government is by far the largest real-estate owner in the country. These holdings are concentrated chiefly in the Western states, where vast areas of the original public domain have been reserved for national forests, national parks, Indian reservations, and other purposes. There are also millions of acres comprising the unreserved public domain for which no use, sufficiently profitable, has yet been found.

Three-quarters of all the country's available water-power resources are found in the eleven westernmost states and, as might be expected, many of the potential sites involve United States land. Through the operation of the public land laws prior to the establishment of the policies under which water power and other lands were reserved, the Government's holdings have been reduced to scattered and fragmentary tracts which serve to give merely a minority interest in many important developments. The Government, however, with its sovereign powers may not be dispossessed through ordinary process of condemnation like other small land holders. Therefore, even though its stake in the ownership of numerous sites is small, it is in a position to dictate the terms upon which the entire development may be allowed to proceed. In the exercise of this unlimited authority the Government becomes an important factor relative to many Western projects which otherwise would be controlled solely by the state concerned.

FEDERAL JURISDICTION OVER STREAMS

The interests of navigation which supply the basis for the second element of Federal jurisdiction over certain water-power projects are derived from the fundamental law. The Constitution makes no reference to water power or navigation as such, but Section 8 of Article 1 embraces the following phrase:

> The Congress shall have power . . . to regulate commerce with foreign nations, and among the several States, and with the Indian Tribes.

By these few words the states surrendered to the central Government vast power under which many forms of Federal activity have grown up, including control of the waterways used or useful for the transportation of persons or property in interstate commerce. The definition of navigable waters subject to the control of Congress has been the subject of much controversy. Whether a stream is navigable or not seems to be a mixed question of law and fact.

While uncertainty will arise relative to the navigable status of individual streams, it is evident that many of the country's waterways are subject to Federal jurisdiction, and by the act of March 3, 1899, Congress decreed that "any obstruction not affirmatively authorized by Congress to the navigable capacity of any of the waters of the United States is hereby prohibited." This law has been construed to apply not only to all structures placed in waters actually navigable, but also to such obstructions on non-navigable tributaries which have the effect of substantially impairing the use of "navigable waters" lower down on the stream.

From the foregoing, it is apparent that even though the separate states possess the right to control the use and development of waters within their borders, the

---

From "Federal Relations to Water Power Development," presented at the Annual Meeting of the American Society of Mechanical Engineers, New York, Dec. 1-5, 1930.

National Government with its land ownerships and responsibility to navigation holds a basis for participation in the authorization of many water-power projects. Under existing law the administration of these interests is vested with the Federal Power Commission created in 1920. Prior to 1920 authorization for projects encroaching upon Government land or in navigable waters was obtained in various forms and from various agencies. These permits were of a revocable nature, and the difficulty of financing the cost of large works on leaseholds subject to bureaucratic vagaries led to a demand for legislation which would serve to promote the development of water resources.

FEDERAL WATER-POWER ACT

The Federal water-power act of 1920 is aimed to provide a uniform policy under which all of the permissive actions of the Government might be managed. It authorized the granting of licenses which are in the nature of limited leases for 50 years. Development by private capital or public agencies was encouraged to the fullest extent practicable by limiting hampering restrictions and administrative fees to a minimum. Moreover the licensee was assured a stable tenure by the guarantee of reimbursement for the cost or fair value of improvements in case the lease should not be renewed upon its termination. The law thoroughly recognizes the principle that the exercise of Federal jurisdiction should be subordinated to that performed by the states in their rightful fields.

In preference to setting up an entirely independent agency for carrying out the functions of the law, Congress chose to have the work continued by the technical staffs of the departments, composing the Commission of the heads of the three departments concerned. Pursuant to recommendation by the President, the last Congress authorized the substitution of full-time commissioners.

The law now has had ten years of trial, and it seems appropriate that inquiry be made concerning accomplishments and as to whether it is serving to encourage water-power development as intended. This decade has been characterized by enormous growth and expansion in the electric industry; consumption of electrical energy has increased 137 per cent, while the population has grown only 16 per cent. The rapidly expanding demand has created the need for huge new sources of production, and many noteworthy water-power plants have been constructed.

ACTIVITIES POWER COMMISSION

A substantial proportion of the new construction has been carried forward under the provisions of the Federal water-power act. Altogether the Commission has granted licenses for 449 projects. Only 107 of these are in the so-called major classification, larger than 100 hp., the others relate to minor projects and segments of transmission lines crossing Government land. Geographical distribution of the licensed projects shows great concentration in the Western states. California alone accounts for more than a third of the 449 projects, while the three Pacific Coast states together have just about half of the total number. Less than 10 per cent of the projects authorized are situated east of the Mississippi River.

Licenses of chief importance are those covering the 107 major projects, which range in magnitude from small plants constructed to serve isolated communities, to great public-utility developments. The giant generating stations at Niagara, at Conowingo, and on the Sierra Nevada streams of California furnish conspicuous examples of the large modern stations carried out under the existing Federal legislation.

Obviously, many of the proposed projects involve questions of a highly controversial nature, but in handling applications the Commission has moved with such diligence and dispatch that no complaint has been made that construction has been unduly delayed on any legitimate project or that essential interests of the public have not been adequately safeguarded. During the past year the Commission has granted licenses which authorize the installation of more than 1,000,000 hp. During the same period, 30 applications were rejected pursuant to the Commission's endeavors to prevent favorable sites from falling into the hands of speculative enterprises which are unprepared to proceed with construction.

PLANTS UNDER LICENSE

Aggregate capacity of completed plants operating under license amounts to about 2,600,000 hp. This comprises some 25 per cent of all the water-power capacity, and nearly six per cent of the total generating capacity in public-utility service. The Commission has no jurisdiction in respect to water-power developments other than the projects under license, and thus it is apparent that the scope of its authority in respect to the electrical industry as a whole is comparatively limited.

Contrary to popular impression, the Commission has almost no jurisdiction in the field of rate regulation. The law specifically limits the exercise of such functions by the Commission to those licensed projects not controlled by state regulation, and hence there has been little room for the Commission to engage in this function.

Since the authority of the Commission is by no means exclusive in respect to the licensed projects, the administration of the law has required close correlation with the activities of state agencies. In general, these relations have been entirely harmonious and mutually helpful, but at times there has been complaint that the Commission was stretching its authority unduly.

These complaints have related mostly to jurisdiction over projects located entirely on private land along non-navigable tributaries, where the Commission has assumed that the operation of the project works might serve to impair the use of navigable waterways lower down on the stream. The Commission's powers over such developments are rather vague and indefinite under the law, and a number of the states have challenged the Government's constitutional authority. They assert that the assumption of jurisdiction in such cases constitutes a serious invasion of the rights of the states, and interferes unnecessarily with developments of strictly local concern. For guidance in the matter the Commission has recently obtained an interpretation of the law from the Attorney General of the United States. This opinion holds that the Commission, in such cases, may grant licenses embodying terms restricted to those necessary for the protection of navigation. By thus harmonizing the respective jurisdictions of the State and Federal governments so that each may be effective in its proper field, a threatening shadow on the operation of the law will be removed.

◆ ◆ ◆

Governor Performance During System Disturbances

By ***R. C. Buell***
General Electric Company
Schenectady
Associate A. I. E. E.

R. J. Caughey
General Electric Company
Schenectady

E. M. Hunter
General Electric Company
Schenectady
Associate A. I. E. E.

V. M. Marquis
American Gas and Electric Company
New York
Associate A. I. E. E.

Tests show conclusively that steam-electric generators may lose synchronism and pull back into step without giving any conclusive evidence of that fact either at the generator or in the control room.

IN THE PAST few years, the amount of analytical and test work on system disturbances and stability has increased tremendously, but very little of this theoretical or practical activity has dealt with the operation of steam-turbine governors. During 1929 a detailed investigation was made of the governor operation of the two 50,000-kw., single-cylinder, reheat-type turbines at the Stanton steam plant.

This plant is located near Pittston, Pa., and is jointly owned by the Scranton Electric Company and the Pennsylvania Power and Light Company. The steam connections and valves of the turbine are shown schematically in Fig. 1. All governing normally is done by the main control valve at the first stage of the turbine. Each generator has its own transformer bank and 66-kv. bus. Power normally is supplied by generator No. 1 to the Scranton Electric Company, and by generator No. 2 to the Pennsylvania Power and Light Company. The 66-kv. buses are tied together by a bus-tie reactor. Due to this reactor, generator No. 1 tends to swing with the Scranton Electric Company system and generator No. 2 with the Pennsylvania Power and Light system.

Some preliminary tests were made by dropping and picking up load on one of the turbines to be sure that the governor and all other equipment were functioning correctly under normal conditions of system operation; these tests did not indicate anything erratic in the operation.

Since short circuits were to be placed on one of the lines to the Scranton Electric Company from the 66-kv. bus supplied by generator No. 1, calculations were made to deterime the magnitude of the fault currents and the stability limits of the system under short-circuit conditions. Fig. 3 shows the results of these preliminary calculations, which indicated that the system would be stable with a one-conductor-to-ground short circuit, but unstable with a two-conductor-to-ground short circuit, when the generator was carrying full load. These calculations also showed that if the load on the generator was reduced to 25,000 kw. and the short circuit was cleared in less than ¾ sec. the system would be stable. The tests verified the calculations and are summarized in Table I.

Test No. 12, Fig. 4 shows the record of a two-conductor-to-ground short-circuit test. The output of generator No. 1 was reduced from 40,000 kw. to 22,000 kw. and the generator pulled out of synchronism with the rest of the system before the short circuit cleared, but generator No. 2, which was carrying a load of only

---

From "Governor Performance During System Disturbances" presented at the A. I. E. E. Southern District Meeting, Louisville, Ky., Nov. 19-22, 1930.

TABLE I—SUMMARY OF TESTS

Test No.	Initial load in mw. Gen. No. 1	Initial load in mw. Gen. No. 2	Duration of short circuit cycles	Valve control	Stability of system	Fig. No.	Remarks
11	38	30	100	Standard	Stable		1 C. G. Fault
12	40	31	100	Standard	Unstable	4, 5, 6,	2 C. G. Fault
13	25	43	100	Standard	Unstable		2 C. G. Fault
14	25	43	39	Standard	Stable		2 C. G. Fault
20	35	43	..	Standard	..		Load Transfer Test
23	25	43	100	Standard	Unstable	7	2 C. G. Fault
34	38	25	40	Semi-Special	Unstable	5, 8	2 C. G. Fault
50	35	20	..	Special	..	5	Load Transfer Test
51	25	31	98	Special	Stable	10	2 C. G. Fault
52	44	20	19½	Special	Stable		2 C. G. Fault
53	45	20	106	Special	Unstable		2 C. G. Fault

31,000 kw., did not pull out of synchronism. Generator No. 1 increased in speed until it tripped the emergency overspeed governor at 1,960 rev. per min., shutting off all steam input to the turbine. The turbine then drifted down to normal speed and pulled into step with the system 5½ sec. after the short circuit occurred.

A graphic voltage recorder with high-speed feature is normally used to record transient disturbances on this 66-kv. bus. The chart obtained from this instrument during this test is shown in Fig. 5. This chart should also be compared with the voltage chart shown in Fig. 6, which was taken during this test by means of a high-speed photographic recorder. This later type of instrument gives a true picture of the voltage conditions and the comparison illustrates the limitations of graphic instruments as recorders of fast transient phenomena.

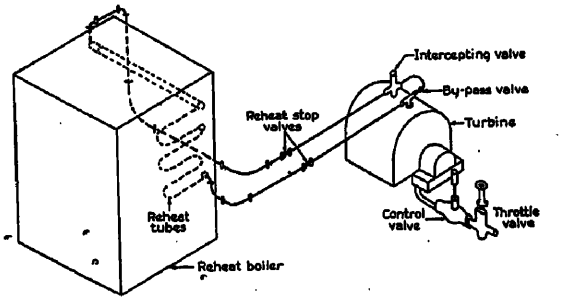


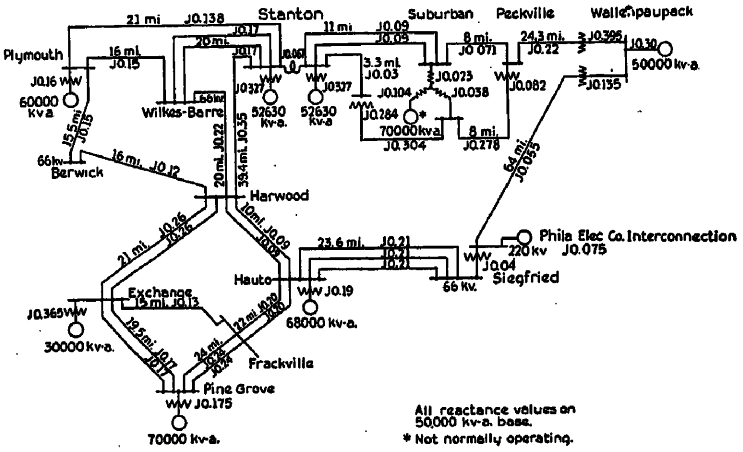
Fig. 1. Schematic diagram of piping and valves for turbines tested

Test No. 23. Calculations had indicated that generator No. 1 would be stable with loads up to 25,000 kw., and a two-conductor-to-ground short circuit duration of less than ¾ sec. A two-conductor-to-ground short circuit was thrown on the system with a 25,000-kw. load on generator No. 1, but due to the relay setting which kept the short circuit on for 1.7 seconds, the generator again went out of synchronism, but did not trip the emergency overspeed governor. Generator No. 2 being heavily loaded (43,000 kw.) lost synchronism with the rest of the system and tripped the emergency overspeed governor. Violent oscillation of the governor beam of generator No. 1 occurred before it resynchronized. Fig. 7 shows the results of these tests.

The relay setting was changed to reduce the short-circuit time to 0.65 seconds and the short-circuit test was repeated. The generators did not lose synchronism, which shows the value of short switching time.

GOVERNOR PUMPING

Load Transfer Tests. Several operating companies have reported that during certain system disturbances the governor beams of the turbines have oscillated, and that this oscillation has continued for two or three minutes, or until some means was taken to correct the condition, such as holding the governor beam or disconnecting the turbine from the system. This phenomenon has been termed generally "governor pumping" and should not be confused with governor hunting which is a slow, periodic movement caused by lag of the valve behind the governor.



All reactance values on 50,000 kv-a. base.
* Not normally operating.

Fig. 2. Single-line diagram of interconnected systems involved in governor tests; only equivalent circuits shown for some parts

Load transfer tests were first made to determine if governor pumping could be produced by a disturbance of a minor magnitude but were unsuccessful.

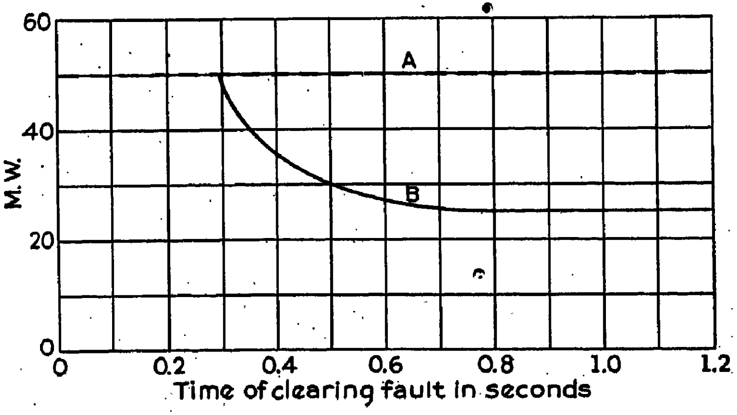


Fig. 3. Power capability of No. 1 generator plotted against switching time; (A) rated megawatts output, (B) output with two-conductor-to-ground fault outside generator transformer

Test No. 34. This was a two-conductor-to-ground short-circuit test in which the generator lost synchronism but did not trip the emergency overspeed governor, so that the speed governor still controlled the steam input. Reduction in the generator output due to the loss in synchronism, coupled with the normal speed-regulating characteristics of the governor, resulted in a sustained prime-mover speed above that of the system.

Fig. 8 shows the results of this test. During the first 2.5 seconds the movement of the main control valve was controlled by an auxiliary pilot valve which was being used in a preliminary form in an attempt to keep the turbine in synchronism; this pilot valve, however, had no effect on the governor or control valve after this initial period. Seven seconds after the short circuit occurred the governor mechanism started to oscillate at a period coinciding exactly with the kilowatt oscillation of the generator. The speed curve shown is a composite curve, composed of an average-speed curve obtained from the oscillograph record, and a superimposed speed change calculated from the output of the generator and added to the average-speed curve. From this composite curve it may be seen that if the governor follows the speed of the turbine it must alternately open and close the control valve an appreciable amount. The curves show that the governor was doing its best to follow these speed changes, although with about ¼ second time lag, and thus was varying the steam input in accordance with the speed, which is what a speed governor is designed to do.

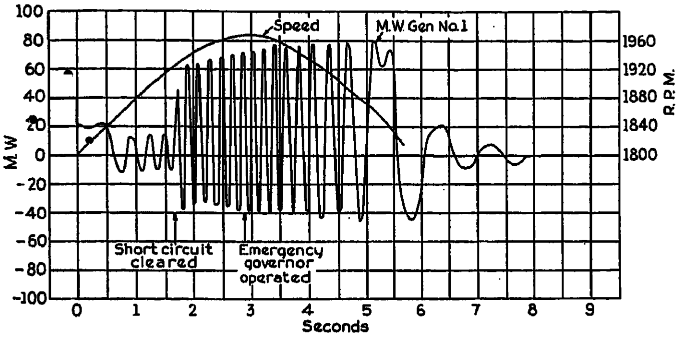


Fig. 4. Test 12. (Two-conductor-to-ground fault) shows No. 1 generator unstable, No. 2 stable

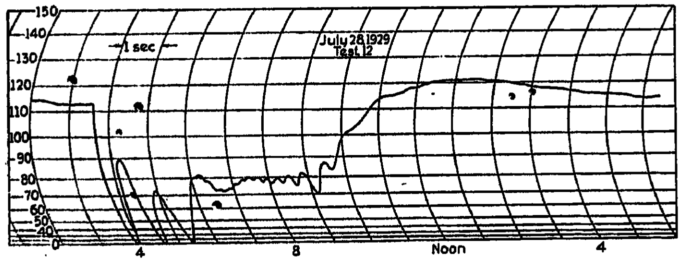


Fig. 5. Test 12. Graphic voltmeter chart from 66-kv.

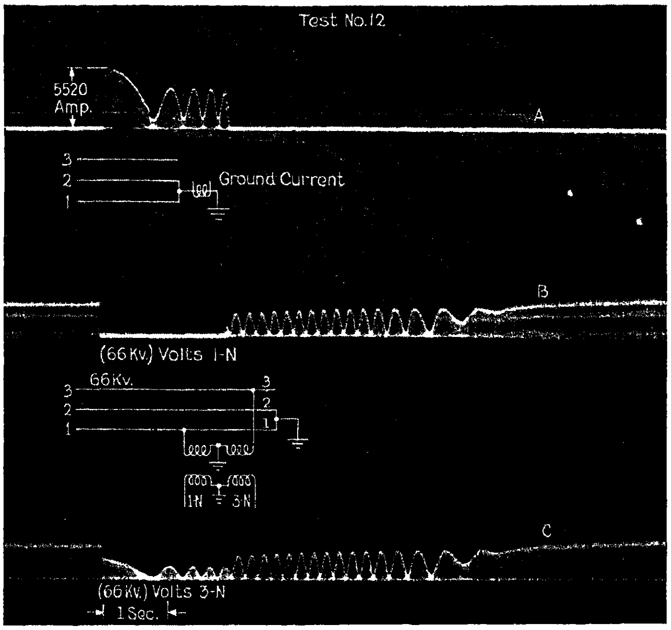


Fig. 6. Test 12. High-speed photographic record of ground current and voltage; (A) fault ground current, (B) voltage, phase 1-N, 66-kv. bus, (C) voltage, phase 3-N, 66-kv. bus

During the interval from the third to the seventh second, the periodic speed change caused by the generator slipping poles was so fast that it was impossible for the control valve to follow it. However, as soon as the average turbine speed came down to a point where the governor mechanism and control valve could follow the periodic changes in speed, the control valve started a pumping movement in which it assumed the proper position corresponding to the speed. This pumping of the governor beam was therefore a normal action and should be expected under conditions such as existed at the time of its occurrence.

Fig. 9 shows the speed-regulation curve for the governor of this turbine at the load carried when this test was made. If the turbine was completely unloaded it would run about five per cent above the normal system speed. The figure also includes a curve showing the relation between speed of the turbine and the induction-generator output of the generator for the voltage conditions which existed on this system during this test. The point where the induction-generator curve crosses the speed-regulation curve determines the speed of the turbine and the load which it will carry when it is out of synchronism. The average output of the generator during the period covered by the curves was about 13,000 kw. and the speed was about 3.3 per cent above normal.

TESTS WITH SPECIAL VALVE EQUIPMENT

In the previous short-circuit tests, all really severe system disturbances were accompanied by a loss of synchronism of one or both of the generators. The possibility of holding this turbine in synchronism by rapid reduction of input steam following a system disturbance seemed in this case to justify investigation. A special power-surge relay and a valve mechanism were designed therefore to shut off the steam input to the turbine by closing the main control and intercepting valves temporarily when a short circuit occurred. In order to obtain a fast reduction in steam input to the turbine it was necessary to operate both the control valve and the intercepting valve on the reheat loop.

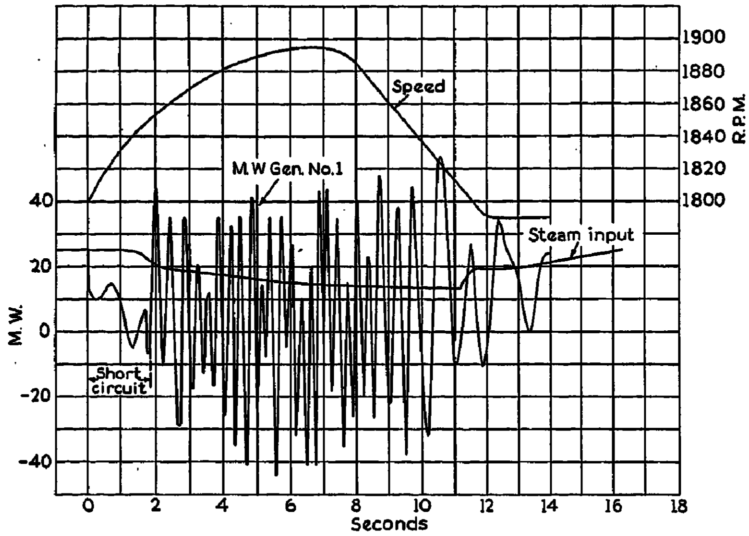


Fig. 7. Test 23. Both generators unstable and out of step with system and each other

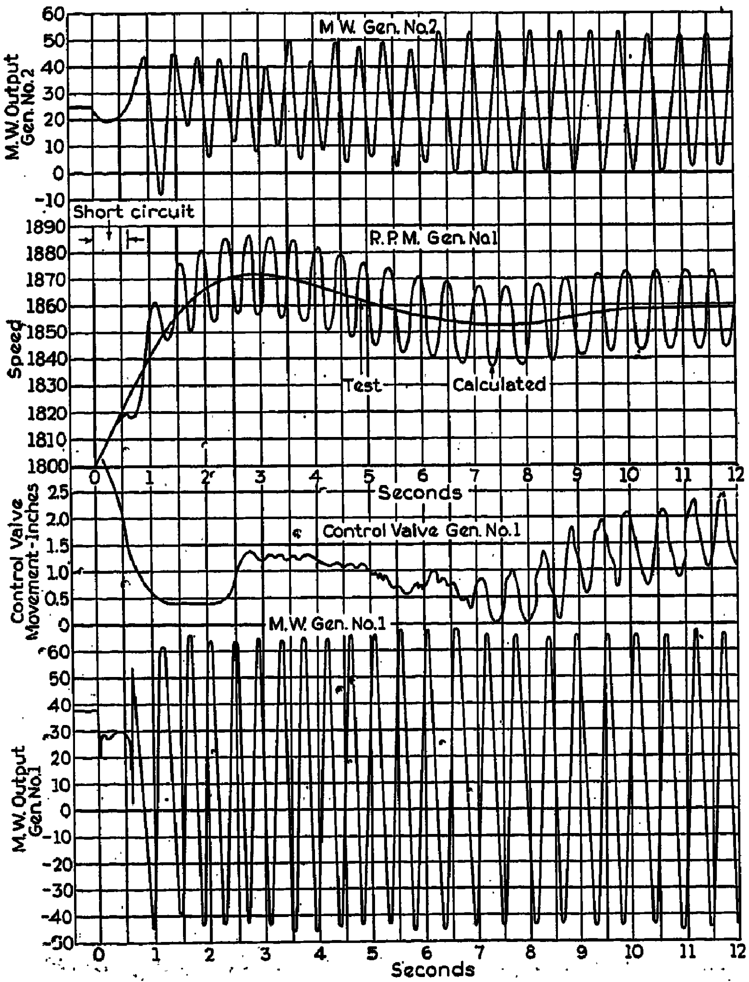


Fig. 8. Test 34. Governor and control-valve pumping

Test 51, Fig. 10 shows the results of a two-conductor-to-ground short circuit on the 66-kv. bus with the kilowatt load on generator No. 1 the same as for tests Nos. 14 and 23, and the short-circuit time the same as for test No. 23. The load on generator No. 2 was, however, somewhat reduced from its previous load. The steam input curve on this figure shows how the high-speed valve mechanisms used in this test, but not in tests Nos. 14 and 23, reduced the input so that the generator not only did not lose synchronism with the rest of the system, but even drifted back in angle so fast that it was taking power as a motor when the short circuit cleared.

Another test was made with full load on generator No. 1, and with the relay adjusted so that it cleared the short circuit in 1.78 sec. Generator No. 1 pulled out of synchronism with the rest of the system and, after slipping 16 poles, pulled back into step again. Although generator No. 1 pulled out of synchronism with the system during this test, it is believed that by a few further refinements in the relay and valve mechanism, it would be possible to keep this generator in synchronism with the rest of the system even for short circuits as severe as in this test.

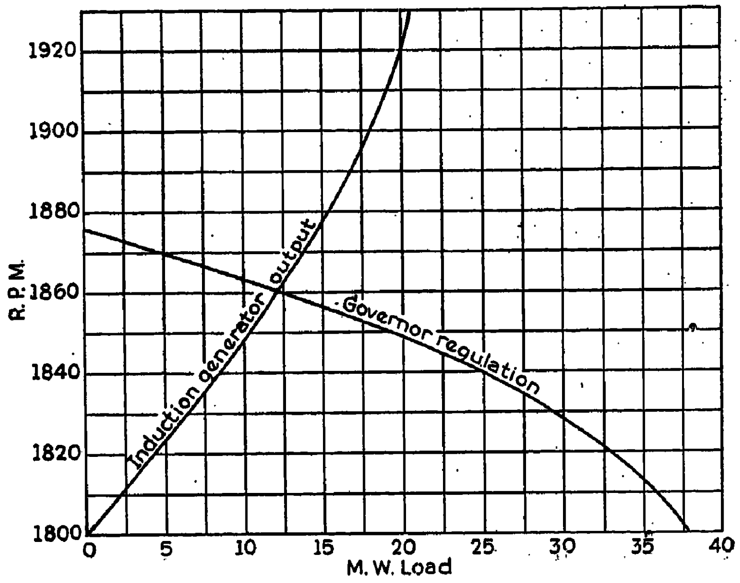


Fig. 9. Test 34. Turbine regulation and induction-generator power

These tests evidence the possibilities of this method for improving system stability and indicate results which are comparable with those obtained by the use of the more commonly proposed means for attaining the same end.

General Summary of Results

Results obtained shed additional light on some phenomena which have occurred during system disturbances and lead to the following general conclusions:

1. It is possible for a generator to lose synchronism and pull back in again without giving any conclusive evidence in the control room or at the turbine that such a change has occurred. Graphic charts and indicating instruments are not fast enough to indicate out-of-synchronism conditions reliably. Thus, this condition occurs far oftener than has been generally appreciated.

2. Cases of sustained system oscillation, or surging, seldom occur unless some generator, or group of generators, loses synchronism. Any oscillation resulting from a disturbance that is not sufficiently severe to cause loss of synchronism quickly dies out, due to the inherent system damping.

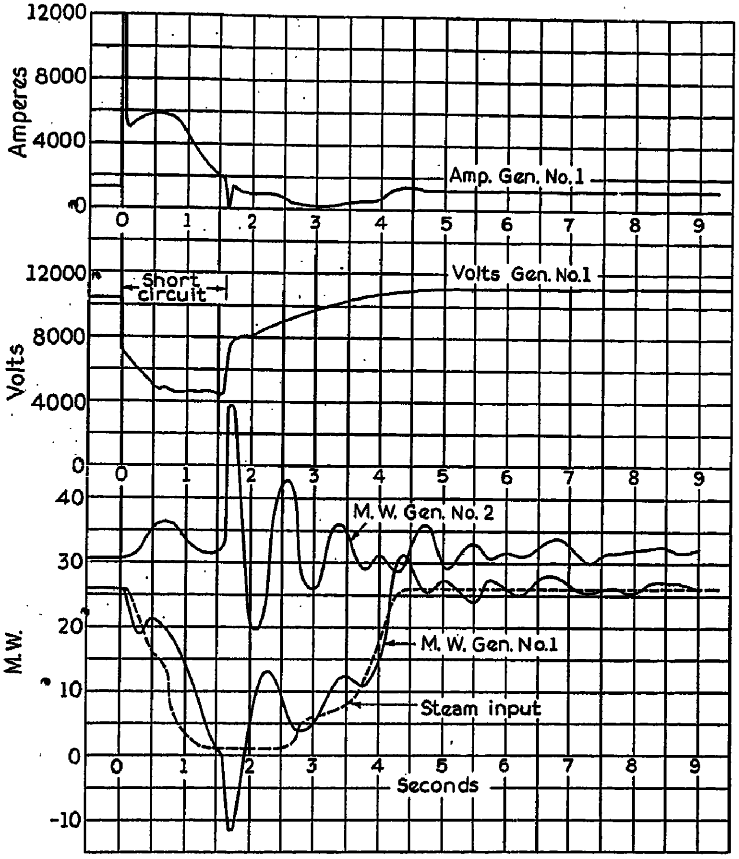


Fig. 10. Test 51. With special valve equipment both generators are stable

3. Governors properly designed and adjusted will not contribute to any system oscillation as long as synchronism is maintained. When out of synchronism, however, the governor attempts to follow the speed change as the generator slips poles, and the result is a "pumping" phenomenon familiar to many station operators. This pumping action is a result rather than a cause of a sustained oscillation and is to be expected when the generator and the system are out of step at a certain slip frequency. It will cease if the generator pulls back into synchronism.

4. When out of synchronism the speed of the turbine is determined by the regulation of the governor and the induction generator characteristics of the generator. The average output during this period may be an appreciable portion of the output before loss of synchronism.

5. In these tests the short circuits resulted in considerable reduction in the kilowatt output of the generators with consequent overspeeding and loss of synchronism. Special valve equipment for quick reduction of steam input following a sudden drop in generator output will increase the stability limits. Under certain conditions it may be of considerable benefit in maintaining stability, but under other conditions the equivalent improvement in stability may be better obtained by other means.

The authors wish to express their appreciation of the cooperation of Messrs. C. H. McKnight and J. E. Geue of the Stanton Operating Company in the performance of these tests and arrangement of system operation with connecting companies. They also wish to acknowledge the assistance of Mr. R. H. Park who initiated the tests with the high-speed valve mechanism, Mr. J. W. Dodge for assistance in the preparation of the test results and Mr. D. M. Jones for criticism of the paper.

BIBLIOGRAPHY

1. TRANSIENTS DUE TO SHORT CIRCUITS, A Study of Tests Made on The Southern California Edison 220-Kv. System, by R. J. C. Wood, Lloyd F. Hunt, and S. B. Griscom, A. I. E. E. TRANS., Vol. 47, January 1928, p. 68.

2. OPERATING CHARACTERISTICS OF TURBINE GENERATORS, by T. E. Purcell and A. P. Haywood, A. I. E. E. TRANS., Vol. 49, April 1930, p. 715.

3. LOAD DUMP TESTS MADE ON COLFAX TURBINES, by T. E. Purcell, *Power*, 1929, Vol. 69, I, p. 590, II, p. 627.

4. SYNCHRONIZED AT THE LOAD, A Symposium, by A. H. Kehoe, A. B. Griscom, H. R. Searing and G. R. Milne, A. I. E. E. TRANS., Vol. 48, October 1929, p. 108.

5. SYSTEM STABILITY AS A DESIGN PROBLEM, by R. H. Park and E. H. Bancker, A. I. E. E. TRANS., Vol. 48, January 1929, p. 170.

6. PROGRESS IN THE STUDY OF SYSTEM STABILITY, by I. H. Summers and J. B. McClure, A. I. E. E. TRANS., Vol. 49, January 1930, p. 132.

7. STABILITY OF SYNCHRONOUS MACHINES, Effect of Armature Circuit Resistance, by C. A. Nickle and C. A. Pierce, A. I. E. E. TRANS., Vol. 49, January 1930, p. 338.

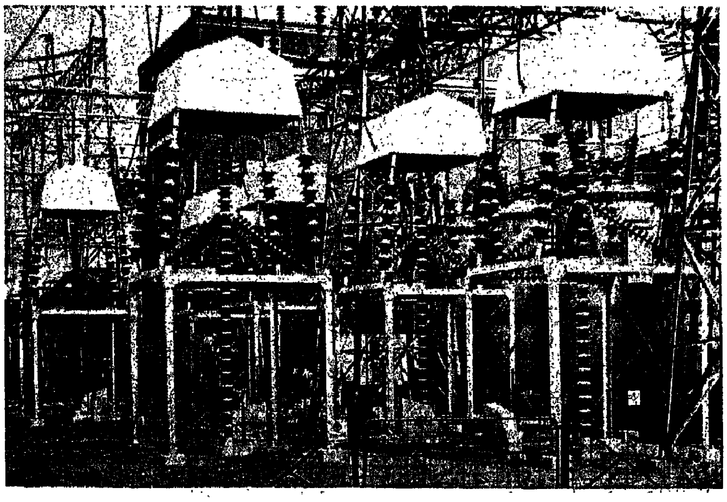
8. POWER LIMIT TESTS, by S. Murray Jones and Robert Treat, A. I. E. E. TRANS., Vol. 48, January 1929, p. 268.

9. EFFECT OF ARMATURE RESISTANCE UPON HUNTING OF SYNCHRONOUS MACHINES, by C. F. Wagner, A. I. E. E. TRANS., Vol. 49, July 1930, p. 1011.

◆ ◆ ◆

Lightning Arresters for 268.4-Kv. Service

THE highest-voltage lightning arresters ever built were recently installed by the Hydro-Electric Power Commission of Ontario. Under emergency conditions they will protect line voltages as high as 268,400 volts. This is also the largest arrester installation for voltages over 200,000. One three-phase arrester protects each of four banks of transformers on



These lightning arresters act automatically to protect against effects of waterwheel overspeed the 220,000-volt transmission line from Paugan to Leaside.

The disparity between the 268,400-volt rating of the arresters and the normal line voltage of 220,000 is a recognition of the inherent tendency of waterwheel generators, if the load is suddenly dropped, to overspeed, carrying the line voltage far above normal. Ordinarily, this situation has been met merely by using arresters rated high enough to withstand the maximum voltage without discharge. But this means that the line has less protection against lightning than were the arresters of only normal line voltage.

The Hydro-Electric arresters meet the situation by having a double rating, changing from one to the other automatically in emergency. Of the series of 22 auto-valve units in each phase leg, only 18 are necessary for 220,000-volt protection, and normally the other four are short-circuited by a high-speed automatic switch. When waterwheel overspeed and over-voltage occur, a relay opens this switch in less than half a second and cuts in the four remaining elements before the line voltage exceeds the limit of the 18 normally in circuit, thus providing protection at 268,400 volts.

An idea of the physical magnitudes involved in such voltages is gained from the fact that the gap sheds are large enough to accommodate an automobile. The arresters were built by the Canadian Westinghouse Company, Ltd.

◆ ◆ ◆

Noise Measurements

That noises have a detrimental effect upon human health and happiness has been proved and now efforts are under way to control or eliminate objectionable sounds. Some of the problems involved are outlined and a newly developed "noise meter" is described.

By John C. Steinberg

Bell Telephone Laboratories, Inc.

THE INCREASING number during recent years of papers and editorials on city noise is evidence of a thriving interest in this aspect of modern life. People are questioning the necessity of this or that noise; makers of machines are looking for ways and means of attaining quieter operation; office and factory managers are asking about the effects of noise on the efficiency of employees; doctors and health officers are becoming interested in the effects of noise on the health of communities; and so on. Noise in this broad sense refers to any audible sound which is undesirable or which intrudes.

Within the past year there has been formed by Health Commissioner Wynne, the Noise Abatement Commission of New York City, and some 10,000 actual noise measurements have been made on the streets of New York. (A recent book, *City Noise*, by the commission, gives a comprehensive report of these measurements as well as other aspects of the noise abatement problem. This report may be secured from the Noise Abatement Commission, Department of Health, City of New York.) It is noteworthy that at one residential and two business locations the noise levels averaged over 15-min. intervals remained practically constant over a 24-hr. period, and the instant-to-instant levels for a 15-min. interval varied by as much as 30 or 40 db. Although these measurements were made at only three locations, they indicate that many residents of a large city are constantly immersed in a sea of noise, the average level at 3:00 a. m. being only a few decibels lower than the level during busy hours.

At this point it may be well to digress to the extent of making clear just what the term decibel really means. On the decibel scale, the unit is actually about equal to the smallest change which the ear can detect in the power level of a sound. Thus it is a ratio of intensity based upon the minimum audible unit; for instance, if the intensities of two sounds are in the ratio of 10:1, the sounds differ in level by 10 db.; if the ratio of intensities is 10^2:1 (100:1), the sounds differ by 20 db. In general, the number of decibels measuring the difference in level between two sounds is ten times the common logarithm of the intensity ratio, or power ratio.

It is a well established fact that constant exposure to noise takes its toll in the form of the extra energy needed to carry on the normal living processes with a consequent more rapid deterioration of the physical and nervous system. Experiments with typist and comptometer operators working under noisy and quiet conditions have shown that the effect of noise is to reduce the rate of accomplishment and to increase the rate of energy consumption by the body. (*Effect of Noise on Working Efficiency*, D. A. Laird, Loc. Cit. 1, and *The*

Based upon an oral presentation at the A. I. E. E. Middle Eastern District Meeting, Philadelphia, Oct. 13-15, 1930.

Effects of Noise, D. A. Laird, *Journal* Acoustical Society Jan. 1930.) Some of its physiological effects are an increase in brain pressure; a lessened regularity of the involuntary muscular changes of body organs such as heart rhythm, stomach rhythm, etc.; an increase in body movements during sleep; and probably in some cases a definite neurosis.

Since machines are the most common source of noise, the subject touches all fields of engineering. Such aspects of machinery as dependability, cost, safety, appearance, etc., have been the constant objects of engineering effort. Only recently, however, has the matter of noise emitted by machines begun to receive the serious attention of engineers.

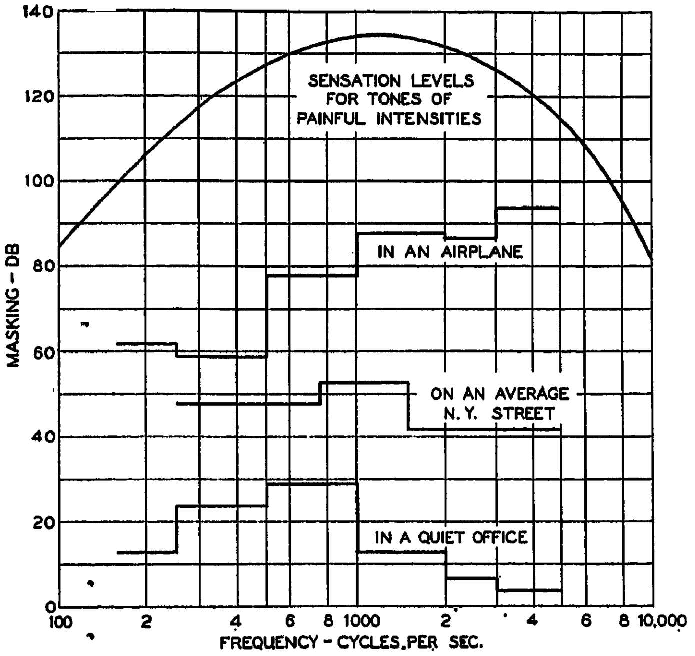


Fig. 1. An audibility chart showing how noises rob the human ear of an important part of its total range

Any study of noise naturally calls for a method of measuring and expressing the amount of noise. From a physical standpoint, this may be done in terms of the total sound energy and its distribution in frequency, and various methods have been devised and used to measure the physical energy of sound waves. For many purposes, however, it is desirable to express noise in terms that are more nearly related to the sensation caused by sound energy.

One method of doing this, called the audiometric method, is based on the fact that noise or the undesired sound masks other or desired sounds. ("Speech and Hearing," H. Fletcher, D. Van Nostrand Co., 1929, and "Auditory Masking," R. L. Wegel and C. E. Lane, *Phys. Rev.*, Feb. 1924.) If a certain intensity is necessary for a sound to be barely audible in a quiet place a greater intensity will be needed in the presence of noise. This shift in threshold is expressed in decibels; *i. e.*, ten times the common logarithm of the intensity ratio, and depends upon the intensity frequency spectrum of the noise.

If the masking caused by noise is observed with tones of different frequency, noise audiograms of the type shown in Fig. 1 are obtained. Two of these were with tones warbling through six different frequency ranges, and one with tones warbling through three different ranges. The curves illustrate three types of audiograms in which with increasing frequency the masking respectively increases, remains approximately constant, or decreases. As indicated above, the audiogram curves are "threshold-of-hearing" curves and the effect of noise is equivalent to a temporary hearing loss. In Fig. 1 the direction of increasing hearing loss is in the direction of the positive Y-axis, which is the opposite of the conventional way of plotting audiograms for the hard-of-hearing. (Loc. cit. (3) p. 199.) In the latter case, attention usually is focused on the hearing loss or upon how far the hearing is down from normal; in the former case, attention usually is focused on the amount that the intensity of a sound must be increased above normal to be audible in the presence of noise.

Useful hearing area in Fig. 1 is that below the curve for tones of painful intensities. The areas below the audiogram curves represent the parts of the useful area which are rendered useless by the noises. In order to be appreciated by the ear, sounds falling within these areas must be increased in intensity to a part of the area above the audiogram curves. For example, average speech as heard at a distance of from three to four feet from the speaker occupies the area between 60 and 70 db. Therefore, on an average New York street, it is only slightly above audibility; and in an airplane cabin becomes entirely inaudible.

The noise audiogram shows directly the loss in serviceable hearing caused by noise. For this reason it is very useful in many noise studies, particularly in the communication field and in the acoustic treatment of auditoriums, theaters, offices, etc., or where the chief concern is the perception of desired sounds in the presence of undesired sounds.

Amounts of noise may be expressed in terms of the sensation level and in terms of the loudness level of the noise. The sensation level is the ratio, expressed in decibels, of the noise intensity to the threshold intensity of the noise. If the intensity spectrum of the noise is known, the sensation level in most cases may be determined from the known minimum audible intensities of pure tones. The loudness level of a noise is usually expressed as the sensation level of some arbitrarily selected reference tone which sounds as loud as the noise.

Masking caused by a noise is measured by adjusting the intensity of a tone from a telephone receiver until it is just audible in the presence of the noise. The receiver is provided with a special offset cap which holds the receiver away from the ear by a small amount, so that noise may enter the ear simultaneously with the tone. The attenuator which is used to adjust the intensity of the tone is calibrated to read the masking in decibels. In one type of noise audiometer ("Methods and Apparatus for Measuring the Noise Audiogram," R. H. Galt, *Journal* Acoustical Society, Oct. 1929) a series of so-called "warbling" tones is used. These are tones which warble through a small frequency range, the range corresponding to each tone being located in a different part of the audible frequency range. Thus the masking caused by the noise is measured in different frequency ranges and when plotted against frequency gives curves of the type shown in Fig. 1. In another type of audiometer (Loc. Cit. 3) the masking is measured with a so-called "buzzer" tone, which consists of a fundamental frequency of 160 cycles and harmonic overtones, the overtones extending throughout a large part of the audible range.

The loudness level of noise is measured by adjusting the intensity of a reference tone until it sounds as loud as the noise. In this method, known to communication engineers as the balance method, the buzzer type of tone is used as a reference tone in some cases and in other cases, a 1,000-cycle pure tone is used.

In all of the above methods the ear is used in obtaining a judgment of the effects of noise. During the past two years considerable experimental work on devices to represent the effect of noise by the reading of an electrical meter has been done by various investigators of noise. (*A Survey of Room Noise in Telephone Locations*, Williams and McCurdy, A. I. E. E. Jour., Sept. 1930; "Practical Methods of Noise Measurement," by E. E. Free, *Journal* Acoustical Society, July 1930 "The Objective Measurement of Machinery Noise, by F. A. Firestone, *Journal* Acoustical Society, July 1930; "Results of Noise Surveys," R. H. Galt, *Journal* Acoustical Society, July 1930.) In all of these devices the noise energy is picked up by a microphone, suitably amplified and rectified and measured by a d-c. meter. The action of the devices is made to approach that of the ear by means of a "frequency-weighting" network. In some cases the weighting is based on the threshold intensities of pure tones; in other cases, on the intensities needed for pure tones to sound equally loud at some arbitrary loudness level. Although where the time characteristics and manner of integrating the components enter in such a procedure does not completely simulate the ear in its action to complex waves, it represents an advance over any method which neglects the ear entirely.

In most cases, noise meters of this type are calibrated to read the noise level in decibels from some arbitrary reference or zero value, such as the meter reading for a "just audible" tone or noise of a particular type. Noises having equal meter readings are approximately equally loud, the degree of approximation depending upon the similarity in energy frequency distribution of the noises being compared.

Noise meters of this type were used in both the N. Y. Noise Abatement Commission Survey of outdoor noise, and the survey of indoor noise by the joint subcommittee of the National Electric Light Association and the American Telephone and Telegraph Company. The frequency-weighting in these meters was based on the intensities needed for various pure tones to sound as loud as a 1,000-cycle tone having a sensation level of 30 db. Readings which would correspond to the threshold of audibility for a common type of noise were obtained for both meters by reproducing street noise phonographically at a known sensation level. Thus, measured noise levels could be expressed in decibels from the threshold settings. A graphical illustration of the noise level scale is given in Fig. 2 where the levels of

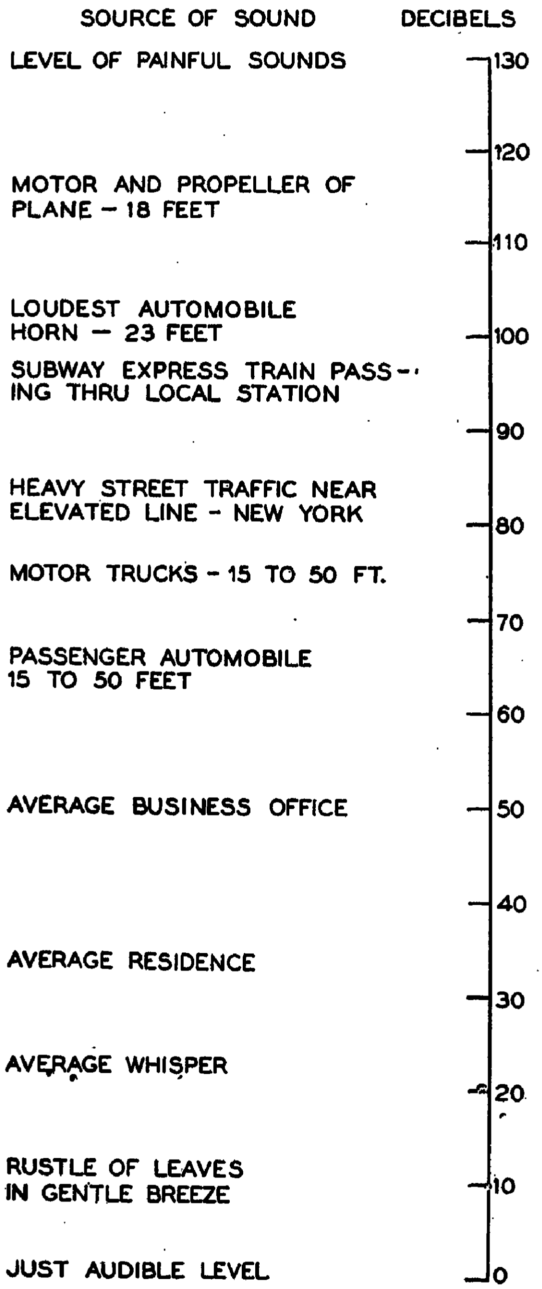


Fig. 2. A chart showing the decibel rating of some common sounds as compared to the "threshold of hearing"

some of the more familiar noises encountered in the surveys may be compared. The total range from threshold to painful sounds is 130 db. It may be seen that ordinary noises cover a large part of this range.

As previously indicated, noise meters such as that described are still in the experimental stage. In order to indicate loudness accurately for all types of sound waves, a meter must simulate the ear in at least three respects:

(a) In the relative sensitivity for sinusoidal waves of different frequencies.

(b) In the integration or summing up of the contributions of the component waves of steady complex sound waves.

(c) In the short-time average of fluctuating complex sound waves.

Further experimental work is needed in order to simulate the ear closely in all of these respects in a practicable noise meter and to determine the effects of various departures on practical noise measurement. The outstanding advantages of the objective type of measurement are that it reduces the personal equation and permits noise measurements to be made with great rapidity.

◆ ◆ ◆

Private-Wire Telegraph Service

An important part of the entire communication service of the United States is devoted to private wire service. More than one and one-half million miles of private wire telegraph service is furnished to press associations, brokers, financial houses, public service companies, and other organizations and individuals. Some of the interesting features involved are described here.

By R. E. Pierce

Telephone Engineer
American Telephone & Telegraph Company,
New York
Associate A. I. E. E.

TELEGRAPHY has the distinction of being the earliest application of electricity in the service of mankind, and it still reigns as an important factor in commercial, educational and social activities. The commercial telegraph message business is essentially a point-to-point service and the telegraph facilities are designed and operated for the most part so as to furnish direct communication channels between two points. The private wire telegraph service, however, usually requires circuits with sending and receiving equipment at more than two points,—often at many points—and because of this fact the engineering problems involved are somewhat different from those in the commercial telegraph field.

Another unique feature of the private wire telegraph service is the fact that it is furnished very largely over plants which are used jointly for telephone and telegraph purposes. Thus if the private wire subscriber having printer service wishes to communicate with the attendants in charge of the maintenance of his service, he has merely to call on the telephone provided for the purpose, usually mounted adjacent to the printer installation. Immediately he is connected directly with the attendants at the printer service position in the nearest telegraph test room. In case of difficulty on the circuit, the telegraph attendant can communicate immediately with distant repeater attendants over test wires provided for the purpose, and with the monitoring printers, can make measurements over the private wire network in question. Transmission measuring apparatus and other testing means are also at his disposal.

The term "private wire telegraph service" as used in this paper covers that type of service by which a complete telegraph communication system is furnished to the patron for his exclusive use; this type of service is sometimes referred to as the "special contract" telegraph service. In that all facilities, including the station apparatus at the patron's premises, are furnished and maintained the service is complete. A circuit may be arranged for either the manual or machine method of operation to suit the requirements of the organization using the service, but since it is the term most universally used, throughout the paper the machine method will be referred to as the "printer method." Other terms in use by various organizations to describe the same method are "typing telegraph," "telephone typewriter," "teletype" and "teleprinter."

COMPARISON OF PRINTERS

The two systems of pointers in common use, the "multiples" and the "start-stop printer," differ in one important feature. In the multiplex system the signals

---

From "Modern Practises in Private Wire Telegraph Service," to be presented at the A. I. E. E. Winter Convention, New York, Jan. 26-30, 1931.

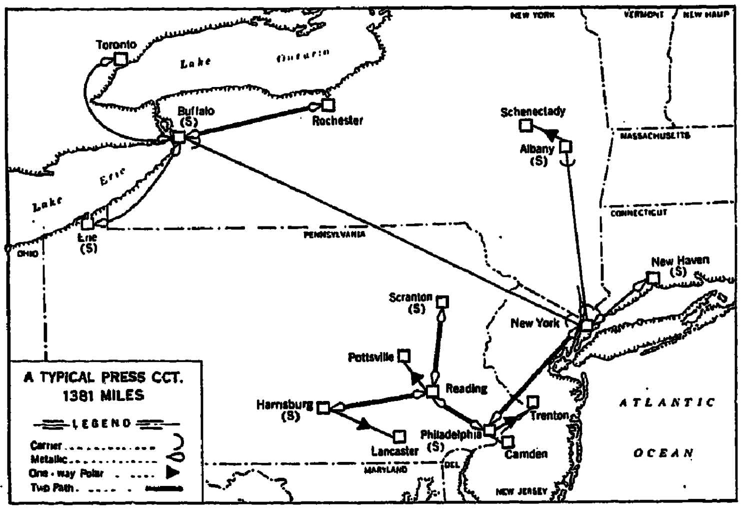


Fig. 1. Typical private press circuit involving 1,381 miles of line

are transmitted to the line and from the line to the receiving apparatus by distributing mechanisms which are operating continuously in approximate synchronism. In the start-stop system the signals are transmitted to the line and from the line to the receiving apparatus. These mechanisms start from a given position, transmit one character and then stop. In this latter arrangement the maintenance of synchronism between the sending and receiving devices is necessary only during the transmission of one letter or character. The multiplex system is essentially a point-to-point system, whereas the start-stop system is adapted to circuits involving a large number of stations, any one of which may send or receive. The advantage of the continuously synchronized system of transmission is the possibility of using a shorter code; it is necessary to transmit only the intelligence-bearing signals, whereas in the start-stop system a signal is sent to start, and another to stop the distant distributor mechanism.

The fundamental advantage of start-stop over continuously synchronized systems is the fact that in the start-stop system the lag in the transmission of a signal from one point to another point in a circuit is automatically taken into account. With only two stations on a given circuit an initial adjustment can be made to properly orient the receiving device with respect to the sending device which will hold as long as the lag remains fixed. With more than two points in a circuit—any one of which may send to all the others—or with transmission systems which are apt to be changed in a way that affects the lag, the adjustment to compensate for lag becomes difficult if not impracticable. This feature would restrict considerably the field of use for continuous synchronism in private wire telegraph service, where such a large portion of the circuit requires service between more than two points, and where it is essential to maintain a flexible plant in order to maintain continuous service. This explanation will indicate why the multiplex system, designed as a continuously synchronized system, is used in the commercial telegraph message service while the start-stop system is used in the private wire telegraph service.

SELECTIVE DIAL CALLING

For services where it is desirable to select particular stations yet impracticable to provide a switchboard with individual circuits to each station, a selective calling arrangement has been developed. With this plan all stations are connected to the same circuit and selective signals are transmitted from one station to another over the circuit used for passing the telegraph signals. The apparatus used to accomplish this consists of telephone dials, step-by-step switches, and relays. Any point on the circuit may be called by dialing any other point on the circuit. A station may also dial by a single three-digit code all other stations or a group of stations. When the circuit is in use, "Busy" signals appear at all stations, and an audible or visible alarm is provided to call the attention of the attendant to an incoming message. When the station is idle the motors of all printers are stopped but start automatically when the station is called and stop automatically when a call releases the circuit. Secrecy is obtained in the system through the fact that it is impossible for a station which has not been called to "listen in" on a circuit in use.

INDUSTRIAL APPLICATIONS

The foregoing gives briefly the general principles of the systems of private wire telegraph service in general use in this country. The following describes special application of private wire systems to various industrial systems:

Press Service. Private wire telegraph service is the means used by the press association for accomplishing quickly, accurately, and without interruption, the collection and distribution of news. A typical telegraph network—one of the many circuits of one of the leading

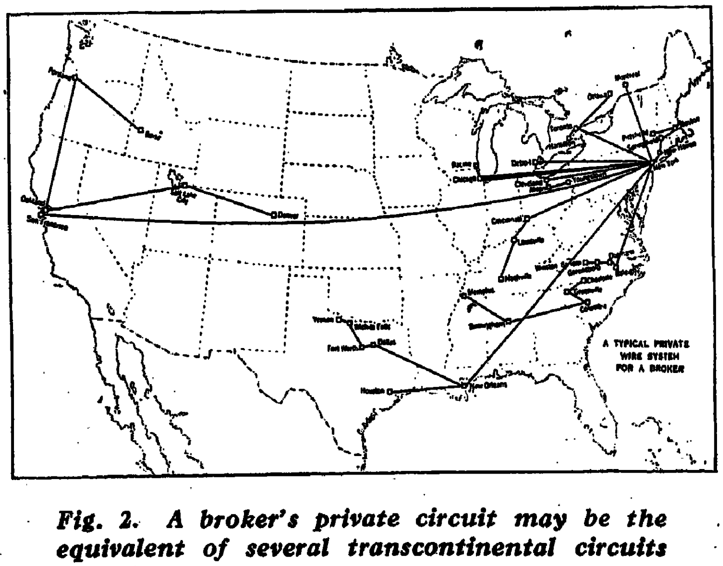


Fig. 2. A broker's private circuit may be the equivalent of several transcontinental circuits

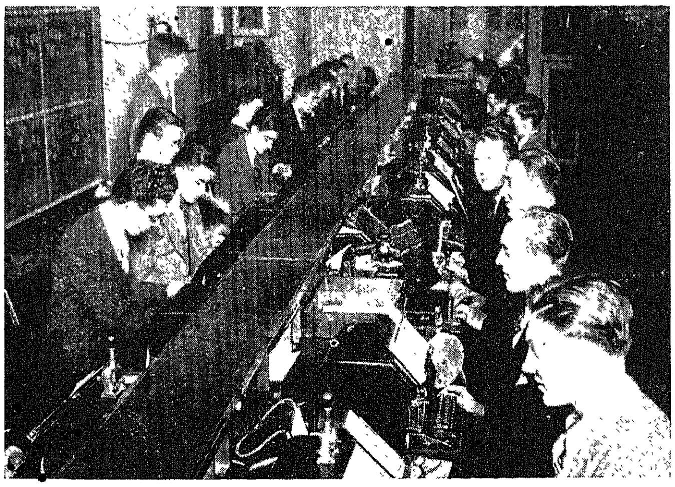


Fig. 3. A broker's private wire room is a busy place

press associations in the United States—is illustrated in Fig. 1. It will be noted that this network contains approximately 1,400 mi. of telegraph circuits and connects sixteen telegraph stations, five of which are arranged for both sending and receiving while eleven are for receiving only. The various types of telegraph systems involved in this particular service are indicated by the designations on the chart.

In a service of this kind most of the sending would be done from New York; it will be noted, however, that there are other points on the network indicated as sending stations. The circuit must be arranged with "break" feature so that when desired, any one of these other sending stations may take control of the entire network and transmit to all stations. To accomplish this the operator at the station transmitting the message operates the break key on his machine which transmits a break signal over the circuit, locking up the machine which has been sending and thereby indicating to the operator at that point that another station wishes to send.

In most cases the printers involved in the press work are of the page type, using a continuous roll of paper. The sending machines are usually equipped for what is known as automatic transmission; the sending operator manipulates a keyboard which controls a perforator. This perforator prepares the message to be transmitted in the form of a perforated tape to be fed into a transmitter connected to the line. The transmitter is operated at a speed for which all the printers on the line are set; the perforator may be operated at any speed desired. If the speed of the line is exceeded by the perforator (as is usually the case) the message is stored up in the tape and is transmitted to the line at a regular rate. With this method of transmission there is a continual flow of traffic over the line and any interruption in the operation of the keyboard does not interrupt the signals going to the line. This arrangement obtains the maximum efficiency from the line.

In certain cases a "bulletin" or "flash" of special importance must be transmitted; arrangements are provided so that by throwing a key the transmission of signals from the perforated tape is stopped and the keyboard is connected directly to the line so that as each key is depressed the proper signals are transmitted. In this way the "bulletin" or "flash" may be sent without delay directly to the line from the keyboard, and when it is complete, the regular flow of traffic may be resumed by restoring the key mentioned previously. In order to attract the attention of the operators at the newspaper offices to such a flash or bulletin, a bell is provided on the printers and caused to ring by the transmission of a particular combination of impulses from the sending keyboard.

Brokers' Service. A large percentage of the business involved in the trading on the stock and commodity exchanges is handled over the private wire systems of the various brokerage concerns. Fig. 2 shows a typical broker's service which comprises several separate circuits. This service is operated by the printer method, and Fig. 3 is a view in one of the wire rooms of this brokerage house. In the brokerage houses the wire network is used for passing information regarding orders placed before the market opens, and for distributing certain market letters or market "gossip." When the market, opens, the wires are kept busy with the passing of orders, confirmations, and questions and answers concerning specific securities. From the illustration it will be noted that the tape printer is used and the cover of the machine cut away in such a fashion as to allow the tape to be removed from the machine immediately after the last character of an order is printed. The orders are gummed on "buy" or "sell" order blanks and are then handled in the usual way. In the afternoon after the market closes the wires, in cleaning up the day's business, continue to handle a large volume of traffic; the records are checked and verified and all matters cleared before the opening of business on the following day. It is reported that during four days of

Fig. 4. Telegraph printer systems are expediting and amplifying effective police work

the record month of October 1929, one of the brokers using this service handled the remarkable total of 49,860 orders, confirmations, and general messages over the firm's six private wire telegraph circuits.

Police Systems. Various police organizations throughout the country are finding the private wire telegraph service a reliable means of quickly disseminating police information. These police systems are essentially broadcasting networks for transmitting police information simultaneously to a large number of receiving stations from one or more central points. The information usually originates in a telephone call or a personal visit to a police station from which the information can be quickly transmitted to the central headquarters and from there sent out on the broadcasting network. Regardless of whether or not the station is attended the receiving machines make a record of the message. In certain cases the receiving machines are equipped with an audible alarm so that a police officer at a distance may be advised that a message is being received. In certain cases it is desirable to provide arrangements whereby the broadcast headquarters will know whether the message is received at each point to which it was transmitted; then an acknowledgment signal is arranged so that after each message is transmitted, the ringing of a bell on the receiving printer indicates that the transmitting station requests an acknowledgment. This can be sent back by pushing a button on the receiving machine, the acknowledgment lighting a lamp on the switchboard at headquarters.

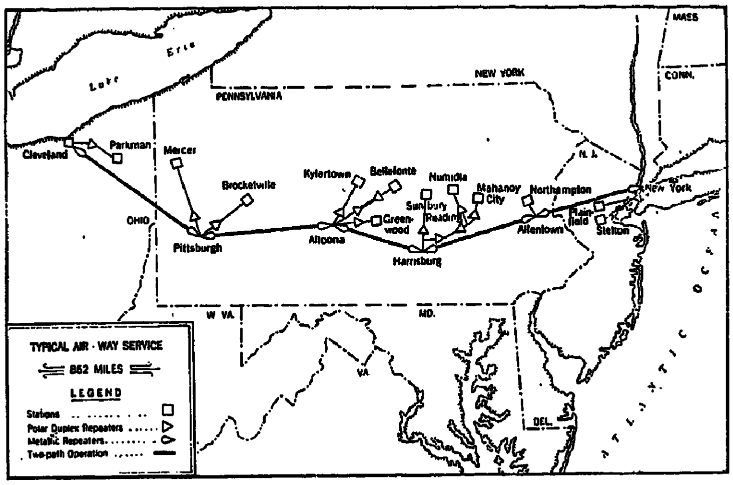


Fig. 5. Communication with planes in flight is becoming of greater importance; this is a typical private airway circuit

Other police networks are set up with all stations connected to the same circuit so that any one may send, and all of the others receive. Such a circuit connects fifteen of the principal municipalities in Connecticut, and in this way police information originating in any of these towns can be broadcast simultaneously to all of the other towns on the network.

Fig. 4 shows one of the switchboards and sending machine in a state police system.

Weather Reporting Systems for Airways. The Department of Commerce has contracted for quite a large network of private wire telegraph circuits for use in collecting and distributing weather information for use by aeroplane pilots. Weather information is collected on an hourly basis in sequence from the principal intermediate landing fields and critical points along an air route. It takes from four to five minutes to make such a weather collection over a typical air route between major landing fields. The weather information thus obtained is furnished to the air pilots before they leave the field or to pilots in the air by means of the radio telephone equipment of the Department of Commerce. Along the air route the printers are usually installed adjacent to the field in what is known as a watch-house. In addition to the service mentioned, in certain local cases private wire circuits are provided for the purpose of distributing weather information between the Weather Bureau, radio stations, airports and air transport companies' offices.

In addition to the collection of weather information the private wire circuit is used in some cases for reporting the departure, arrival, and passing of planes. Fig. 5 shows a typical airway network. The stations along the air route are usually connected in series so that each station receives the information sent from all other stations. In some cases the bell signal on the printer is used to call the attention of a particular station with which it is desired to communicate.

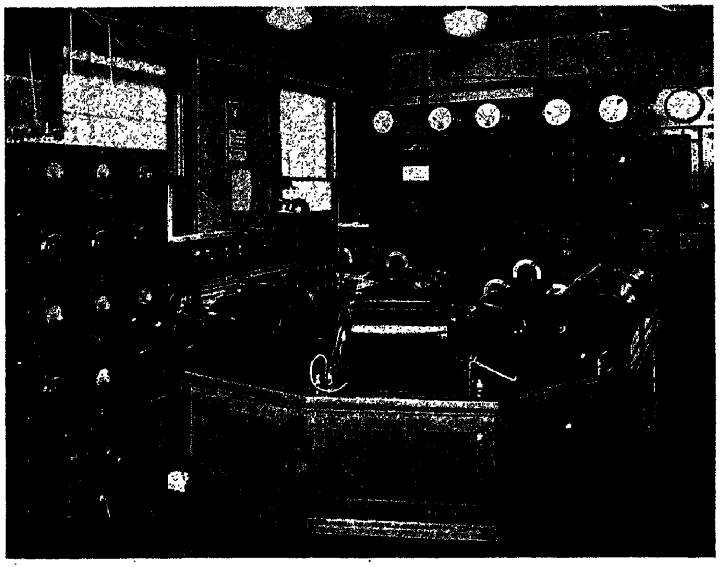


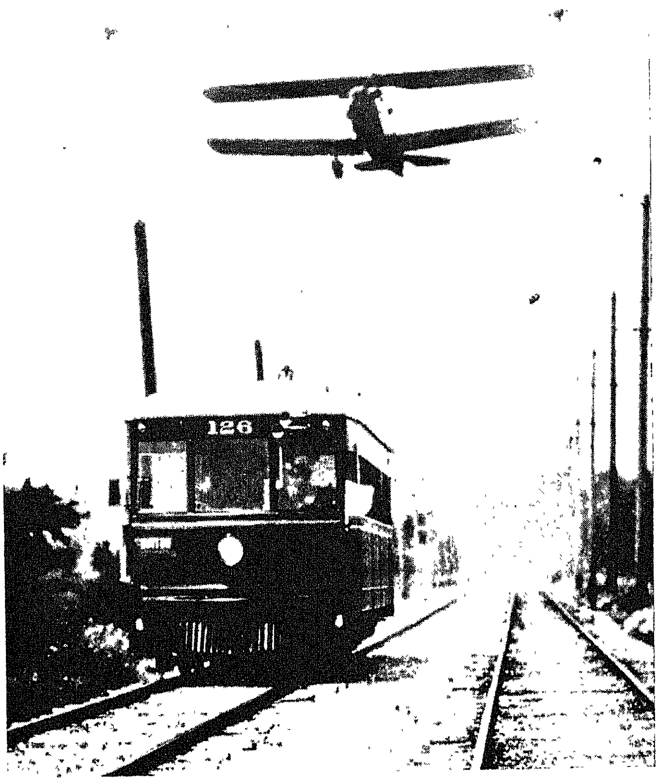
Fig. 6. A modern airway communication office

Manufacturing Service. Factories are generally located with regard to the availability of raw materials and the ease of transportation; executive and sales offices, on the other hand, are usually near the distributor, the exporter or the consumer. Private wire telegraph service is used extensively to provide direct-communication channels between the widely separated units of modern industrial organizations. With the aid of this service the far-flung units of this organization are kept in constant touch with each other, thereby speeding up production and improving the service rendered to their customers.

In looking forward to the future, there seems to be every indication that private wire telegraph service will continue to grow and expand, and with the requirements continually changing it is to be expected that many new and interesting developments will be applied to this service.

◆ ◆ ◆

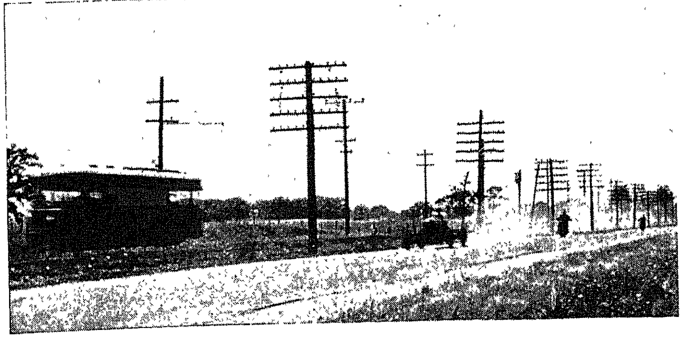
Ninety Miles an Hour in a Trolley Car!



Outwitting the "speed cops"; electric car traveling at more than 90 mi. per hr.

THE fastest interurban cars in the world are leaving competing buses nearly an hour behind on the 225-mile run between Cincinnati and Toledo, though the bus route is shorter by 15 mi. By their owner, the Cincinnati and Lake Erie, these cars have been clocked at 90 mi. per hr. or better. During trials, police motorcycles were left behind, and even the aeroplane scarcely overhauled the "flying" trolley.

Unlike previous extremely fast cars, these are neither very large nor heavy. They weigh but 24 tons, seat 40 people, and are of one-man operation. Their motors rate 100 hp. each, (quadruple equipment) and in the case of the ten Westinghouse equipments, weigh complete but 2,690 lb. How extraordinarily light this is, is shown by contrast with other motors bought by this road in 1927 which weighed half again as much per horsepower. The remarkable lightness of the new motor is partly due to improved insulation, but largely to the high rotative speeds found practicable through its being wound for 300 volts. The principal advantage of the lower voltage, however, is the marked benefit to commutation. The motors are geared 26:46 on 28-in. wheels.



Only an airplane succeeded in overhauling this new interurban electric car

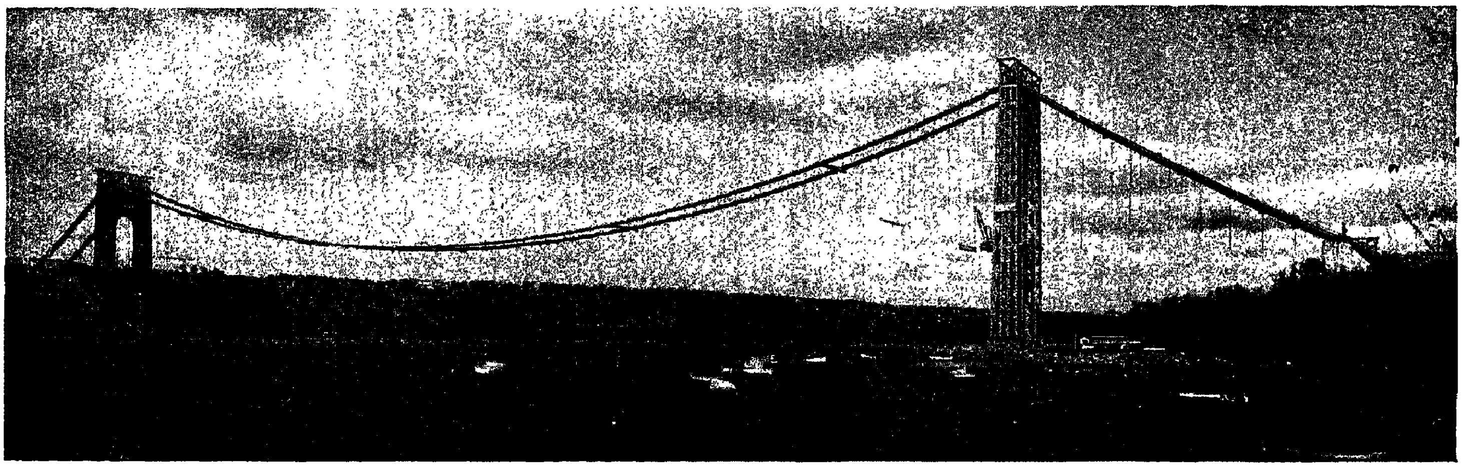
In general, the experience of the Cincinnati and Lake Erie does not show that high speed offers any particular difficulties. The permanent way was put in first-class condition, with especial attention to the safe elevation of curves and the alinement of overhead, but no departure from normal standards was needed.

The interurban roads have had more than their share of post-war difficulties, but the Cincinnati and Lake Erie and its chairman, Doctor Thomas Conway, have produced substantial proof of the rewards that the industry still offers to courage and to vision.

Aeroplanes, automobiles, and yachts race for amusement, but trolley cars do not; they race strictly for revenue. So it is important to observe that in the second month of the new cars, passenger ticket receipts in three of the principal cities had increased 77 per cent. Over Labor Day, 17 of the trains had to be run in two or more sections, and in November it was understood that the cars were, as show people say, "packing them in"—and this on a road which a year ago was not embarrassed by density of traffic any more than is the average interurban road—on a road paralleled by good highways over a shorter route, by first-class buses, and by fast steam trains.

News

Of Institute and Related Activities



The new Hudson River bridge which connects upper Manhattan with the north New Jersey shore is the longest single-span structure in the world

Winter Convention Presents Attractive Program

Engineering Papers, Inspection Trips, and Entertainment of Striking Interest Assure Busy, Profitable Week

MANY excellent developments in various fields of electrical engineering will be brought out in the technical sessions at the A. I. E. E. winter convention. This meeting, which promises to equal in interest any of the past winter conventions, will be held in New York, January 26-30, with headquarters in the Engineering Societies Building. In addition to the excellent technical program there will be a number of interesting trips and good entertainment with a specially arranged program for the ladies.

Technical Sessions

One of the sessions that should prove of general interest is the symposium on coordination between power and communication circuits. The papers which are to be presented represent the work of a joint general committee of the National Electric Light Association and the Bell Telephone System. Each paper was prepared by a representative in the power field and a representative in the communication field jointly. The achievements obtained are a noteworthy example of cooperation between different fields of the electrical profession.

At the opening of the session R. F. Pack, vice-president and general manager of the Northern States Power Company, will make an introductory statement. Following the presentation of the papers closing remarks will be made by Bancroft Gherardi, vice-president and chief engineer of the American Telephone and Telegraph Company. The session should have a broad general appeal and the papers to be presented are not highly technical or mathematical.

Many recent developments involving design, theory, operation, and testing will be brought out in the papers which will be presented in nine other sessions in the fields of telegraphy, transportation, protective devices, power transmission, industrial power applications, electric welding, electrical machinery, and research.

Edison Medal Presentation

The Edison Medal will be presented to Doctor Frank Conrad for his contributions to radio broadcasting and short-wave radio transmission. Presentation will take place in the Engineering Auditorium on the evening of Wednesday, January 28.

Following the presentation ceremonies a lecture will be delivered by Doctor Karl Taylor Compton, president of Massachusetts Institute of Technology.

Smoker

A buffet dinner and smoker will be held in the Engineering Societies Building on Tuesday evening, January 27. This informal occasion affords a splendid opportunity for members and their guests to renew old acquaintances. Plans are being made which will provide very attractive entertainment after the dinner, to be served by Louis Sherry.

Dinner Dance

The dinner dance of the winter convention will be held in the Grand Ballroom of the Hotel Astor on the evening of Thursday, January 29. For many years this annual social event of the Institute has afforded much pleasure to all in attendance and is looked forward to from year to year by a large proportion of the membership. Tickets will be $6 per person. Reservations may be made in advance for tables seating eight people.

LADIES ENTERTAINMENT

The ladies entertainment committee is actively engaged preparing a special program which will prove very attractive for the ladies in attendance.

PROGRAM OUTLINE

MONDAY, JANUARY 26

10:00 a. m.	Registration
2:00 p. m.	Opening of Convention A—Symposium on Telegraphy
8:15 p. m.	B—Joint Session of Committee on Transportation and the Transportation Group of the New York Section

TUESDAY, JANUARY 27

10:00 a. m.	C—Symposium on Coordination of Power and Communication Circuits
2:00 p. m.	D—Session on Protective Devices
6:00 p. m	Buffet Dinner and Smoker

WEDNESDAY, JANUARY 28

10:00 a. m.	E—Session on Power Transmission
2:00 p. m.	Inspection Trips Board of Director's Meeting
8:30 p. m.	Edison Medal Presentation and Lecture

THURSDAY, JANUARY 29

10:00 a. m.	F—Industrial Power Applications
2:00 p. m.	Technical Sessions G and H G—Transportation H—Electric Welding
7:30 p. m.	Dinner Dance

FRIDAY, JANUARY 30

10:00 a. m.	I—Session on Research
2:00 p. m.	J—Session on Electrical Machinery

TRIPS

On the inspection trips offered many prominent developments of interest to the electrical engineering profession may be seen:

1. The Hudson River Bridge with construction work now in progress offers an unusual opportunity for engineers to view a remarkable feat in bridge construction. The main span, 3,500 ft. in length, is the longest single span in the world and is supported between towers which rise to a height of 635 ft. above the water's surface. Four cables each made up of 26,474 wires giving a specified minimum strength of 220,000 lb. per sq. in. and weighing 28,450 tons, support the double-deck structure. Construction work was started in May, 1927, and the initial portion consisting of four traffic lanes and two sidewalks is scheduled to be opened to traffic early in 1931. The ultimate plan provides for eight traffic lanes and two sidewalks on the upper deck with a lower deck to accommodate four rapid transit tracks. The cost of completion of the initial stage of the construction is estimated to be $60,000,000.

2. Vertical distribution in modern skyscrapers such as the Chrysler Building and the Empire State Building. The Empire State is the tallest building in the world.

3. New Eighth Avenue Subway Substations

4. Tandem-compound, 160,000-kv-a., steam-electric generating unit of the New York Edison Company.

5. Modern press installation and lighting of the new Daily News Building.

6. Modern use of light as the sole decorative agent in a large ballroom—St. George Hotel, Brooklyn, N. Y.

7. Railroad electrification as exemplified in the newly completed properties of the Delaware, Lackawanna & Western Railroad.

8. The Westinghouse Lighting Institute.

9. New York Museum of Science and Industry.

10. Roseland switching station of the Public Service Electric and Gas Company (New Jersey).

Details as to transportation tickets, etc., will be announced in the programs distributed at the convention.

REDUCED RAILROAD RATES

Under the certificate plan reduced railroad rates will be available to members and guests who attend the convention; only half fare need be paid on a return trip over the same route, provided a total of at least 150 certificates are deposited at the registration desk. Rates apply to all who attend the convention and to dependent members of their families. Each member or guest should obtain a certificate when purchasing his one-way ticket to New York, explaining to the ticket agent that he wishes the certificate authorized by the passenger associations for the winter convention of the American Institute of Electrical Engineers.

On arriving at the convention the certificate should be deposited at the registration desk. There it will be held for validation by a railroad representative and if 150 or more certificates are validated, these certificates will be returned to the owners. By presenting the validated certificate when purchasing a return ticket, only half fare will be charged. Local ticket agents should be consulted regarding conditions affecting this plan, as it applies only within certain dates, depending upon the territory. *Everyone* whose one-way fare is more than 66 cents *should get a certificate* whether or not he intends to use it. *By neglecting to do so others may be deprived of considerable saving.*

REGISTER IN ADVANCE

Each member should register in advance by mail, thus permitting the committee in charge to have the badges ready, resulting in a considerable saving of time and congestion at the registration desk.

COMMITTEES

The 1931 winter convention committee is constituted as follows: H. P. Charlesworth, Chairman; J. B. Bassett, C. R. Jones, H. A. Kidder, G. L. Knight, A. E. Knowlton, E. B. Meyer, C. E. Stephens and R. H. Tapscott.

Chairmen of subcommittees are, respectively: J. B. Bassett, convention executive committee; W. R. Smith, inspection trips; E. J. Johnson, dinner dance; G. W. E. Draper, smoker; and Mrs. E. B. Meyer, ladies entertainment.

HOTEL RESERVATIONS

Reservations for hotel accommodations should be made by writing directly to one of the hotels listed in the mailed announcement of this convention.

Newly electrified section of Lackawanna suburban lines serving New York City

Technical Program

January 26—2:00 p. m.

Opening of Convention

Remarks by President William S. Lee.

Statement by A. E. Knowlton, chairman, meetings and papers committee.

A—Symposium on Telegraphy

Presiding officer: H. S. Osborne, vice-chairman, of the committee on communication.

The Newfoundland-Azores High-Speed Duplex Cable, by J. W. Milnor, C. H. Cramer, W. D. Cannon, and J. A. Randall, Western Union Telegraph Company.

Submarine Cable Telegraphy; Influence of Interference, by J. W. Milnor, Western Union Telegraph Company.

Telegraph Transmission Testing Machines, by F. B. Bramhall, Western Union Telegraph Company.

A Printing Telegraph Concentrator, by W. B. Blanton, Western Union Telegraph Company.

Modern Practises in Private Wire Telegraph Service, by R. E. Pierce, American Telephone and Telegraph Company.

January 26—8:15 p. m.

B—Joint Session on Transportation

The New York Section's Transportation Group and the A. I. E. E. Committee on Transportation jointly participate in this session.

January 27—10:00 a. m.

C—Symposium on Inductive Coordination

Presiding officer: A. E. Knowlton, chairman of the meetings and papers committee.

Introductory statement by R. F. Pack, vice-president and general manager of the Northern States Power Company.

Trends in Telephone and Power Practise as Affecting Coordination, by W. H. Harrison, American Telephone and Telegraph Company, and A. E. Silver, Electric Bond and Share Company.

Status of Joint Development and Research on Noise-Frequency Induction, by O. B. Blackwell, American Telephone and Telegraph Company, and H. L. Wills, Georgia Power Company.

Status of Joint Development and Research on Low-Frequency Induction, by R. N. Conwell, Public Service Electric and Gas Company, and H. S. Warren, American Telephone and Telegraph Company.

Status of Cooperative Work on Joint Use of Poles, by J. C. Martin, Midwest Utilities Company, and H. L. Huber, American Telephone and Telegraph Company.

Closing statement by Bancroft Gherardi, vice-president and chief engineer of the American Telephone and Telegraph Company.

January 27—2:00 p. m.

D—Session on Protective Devices

Presiding officer: Raymond Bailey, chairman of the committee on protective devices.

An Experimental Lightning Protector for Insulators, by J. J. Torok, Westinghouse Electric & Manufacturing Company.

Field Tests on Thyrite Lightning Arresters Using Artificial Lightning of 1,500,000 Volts, by K. B. McEachron and E. J. Wade, General Electric Company.

Series Resistance Method of Increasing Transient Stability Limit, by R. C. Bergvall, Westinghouse Electric & Manufacturing Company.

Trend in Development of Modern Circuit Interrupters, by J. B. MacNeill, Westinghouse Electric & Manufacturing Company.

Philo 1930 Oil Circuit Breaker Tests (aims, set-up and results from a system and operating point of view), by Philip Sporn and H. P. St. Clair, American Gas and Electric Company.

The Oil-Blast Circuit Breaker, by D. C. Prince and W. F. Skeats, General Electric Company.

Field Tests on Standard and Oil Blast Explosion Chamber Oil Circuit Breakers, by R. M. Spurck and H. E. Strang, General Electric Company.

January 28—10:00 a. m.

E—Session on Power Transmission

Presiding officer: P. H. Chase, chairman of the committee on power transmission and distribution.

Traveling Waves on Transmission Systems, by L. V. Bewley, General Electric Company.

Impulse Tests on Substations, by A. S. Brookes and R. N. Southgate, Public Service Electric and Gas Company, and W. G. Roman and E. R. Whitehead, Westinghouse Electric & Manufacturing Company.

Lightning Investigation on a Wood-Pole Transmission Line, by J. J. Torok, Westinghouse Electric & Manufacturing Company, and R. R. Pittman, Arkansas Power and Light Company.

1929 Lightning Experience on the 132-Kv. Transmission Lines of the American Gas and Electric Company, by Philip Sporn, American Gas and Electric Company.

Attenuation and Successive Reflections of Traveling Waves, by James C. Dowell, General Electric Company.

January 29—10:00 a. m.

F—Session on Industrial Power Applications

Presiding officer: C. W. Drake, chairman of the committee on general power applications.

Electron Tubes in Industry, by W. R. King, General Electric Company.

Automatic Regulators in Industry, by J. H. Ashbaugh, Westinghouse Electric & Manufacturing Company.

Electrical Distribution Systems for Industrial Plants, by W. J. McClain and Louis T. Klauder, consulting engineers.

The Synchronous Motor with Phase-Connected Damper Winding as a Drive for High-Torque Loads, by M. A. Hyde, Jr., Westinghouse Electric & Manufacturing Company.

The Design and Application of Synchronous Motors to Meet Special Requirements, by D. W. McLenegan and A. G. Ferriss, General Electric Company.

Weather Making—A Public Service and a New User of Power, by D. C. Lindsay, Carrier Engineering Corporation.

January 29—2:00 p. m.

G—Session on Transportation

Presiding officer: Sidney Withington, chairman of the committee on transportation.

Lackawanna Suburban Electrification, by E. L. Moreland, Jackson and Moreland, Engineers.

Motive Power for Suburban Electrification, by Charles Kerr, Jr., Westinghouse Electric & Manufacturing Company.

Transverse Fissure Detector Car, by H. C. Drake, Sperry Products, Inc.

Inclined Catenary Calculations, by B. M. Pickens, Westinghouse Electric & Manufacturing Company.

Design of Catenary System for Cleveland Union Terminal, by N. F. Clement and E. E. Richards, Cleveland Union Terminals Company.

January 29—2:00 p. m.

H—Session on Electric Welding

Presiding officer: P. P. Alexander, chairman of the committee on electric welding.

Some Experiments with Arcs between Metal Electrodes, by G. M. Shrum and H. G. Wiest, Jr., General Electric Company

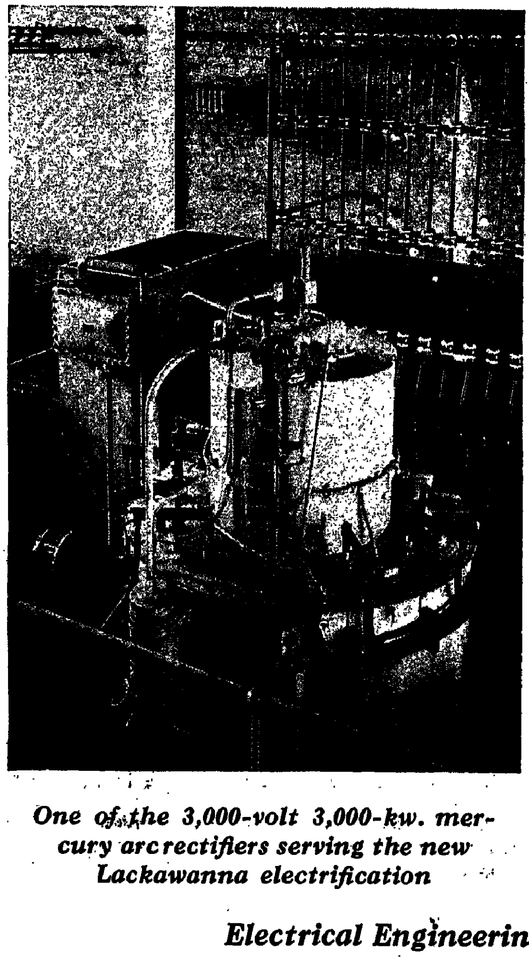
An Improved Arc-Welding Generator, by J. H. Blankenbuehler, Westinghouse Electric & Manufacturing Company.

The Neutralized Welder—A Means of Controlling Transients, by F. Creedy, Lehigh University.

A System for D-C. Arc Welding, by S. R. Bergman, General Electric Company.

Resistance Welding of Motor Frames, by Malcolm Thomson, General Electric Company.

Electric Resistance Brazing, by Samuel Martin, Jr., General Electric Company.



One of the 3,000-volt 3,000-kw. mercury arc rectifiers serving the new Lackawanna electrification

January 30—10:00 a. m.

I—Session on Research

Presiding officer: L. W. Chubb, chairman of the committee on research.

Some Electrical Characteristics of Cable Oils, by H. H. Race, General Electric Company.

The Conductivity of Insulating Oils—II, by J. B. Whitehead, Johns Hopkins University.

Fundamental Properties of Impregnated Paper, by J. B. Whitehead and W. B. Kouwenhoven, Johns Hopkins University.

Traffic Control by Light Beams, by R. C. Hitchcock, Westinghouse Electric & Manufacturing Company.

Commutation and Current Collection in Hydrogen, by R. M. Baker, Westinghouse Electric & Manufacturing Company.

The Helical Groove, by G. M. Little, Westinghouse Electric & Manufacturing Company.

Studies in Non-Linear Circuits, by C. G. Suits, General Electric Company.

January 30—2:00 p. m.

J—Session on Electrical Machinery

Presiding officer: P. L. Alger, chairman of the committee on electrical machinery.

Mercury Arc Rectifier Research, by A. W. Hull and H. D. Brown, General Electric Company.

Effect of Transient Voltages on Power Transformer Design—III, by K. K. Palueff, General Electric Company.

Stationary Flow of Heat in Large Turbine Generators, by C. Richard Soderberg, Westinghouse Electric & Manufacturing Company.

Induction-Motor Slot Combinations, by Gabriel Kron, United Research Corporation.

The Pulling into Step of a Salient-Pole Synchronous Motor, by H. E. Edgerton and Paul Fourmarier, Massachusetts Institute of Technology.

◆

Professional Committee Appointed to Study Engineer Licensing

To provide for closer cooperation of the Institute with the American Engineering Council in all matters connected with the improvement of the general status of the engineering profession, President Schuchardt was, in March 1929, authorized by the Board of Directors to appoint a representative to serve on the Council's committee on engineering and allied technical professions, with the understanding that this representative would become chairman of an Institute committee if it later became desirable to establish a separate committee. H. A. Kidder, superintendent of motive power, Interborough Rapid Transit Co., New York, was appointed the A. I. E. E. representative.

The Board of Directors, in August 1929, authorized the president to appoint a committee on the engineering profession to consider various matters affecting the status of the engineering profession, to cooperate with the American Engineering Council committee on engineering and allied technical professions, and to assume the duties of the A. I. E. E. committee on licensing of engineers which was, at the same time, discontinued. To serve with Chairman Kidder, President Smith appointed T. F. Barton, H. P. Charlesworth, and John C. Parker.

President Lee reappointed the four named above for the present administrative year, and, in accordance with authority granted by the Board of Directors in October 1930, has enlarged the committee to include the membership given below:

H. A. Kidder, (Chairman), supt. of motive power, Interborough Rapid Transit Co., 600 West 59th St., New York, N. Y.

J. P. Alexander, Boston manager, Westinghouse Elec. & Mfg. Co., 10 High St., Boston, Mass.

T. F. Barton, district engineer, General Electric Co., 120 Broadway, New York, N. Y.

B. M. Brigman, dean, Speed Scientific School, University of Louisville, Louisville, Ky.

H. P. Charlesworth, vice-president, Bell Telephone Laboratories, Inc., 463 West St., New York, N. Y.

L. F. Leurey, consulting electrical engineer, 58 Sutter St., San Francisco, Calif.

L. W. Morrow, editor, *Electrical World*, Tenth Ave. at 36th St., New York, N. Y.

John C. Parker, vice-president in charge of engineering, Brooklyn Edison Co., Inc., 380 Pearl St., Brooklyn, N. Y.

John R. Price, professor of electrical engineering, University of Wisconsin, Madison, Wis.

Herbert S. Sands, consulting engineer, 1115 First National Bank Building, Denver, Colo.

Maurice R. Scharff, consulting engineer, Main & Co., accountants and auditors, First National Bank Building, Pittsburgh, Pa.

H. H. Schoolfield, chief engineer, Pacific Power & Light Co., 607 Public Service Bldg., Portland, Oregon

W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

J. B. Thomas, vice-president, Electric Service Co., Fort Worth, Texas

Although this committee has several very important fields of activity, it is at present devoting its principal efforts to cooperation with other organizations in the development of suitable provisions for the licensing of engineers. Through this committee and its close cooperation with the American Engineering Council committee named above, the Institute is in position to participate actively in efforts to solve problems affecting the status of the engineering profession.

◆ ◆ ◆

A. I. E. E. Nominating Committee Announces Official Candidates for 1931

A COMPLETE official ticket of candidates for the Institute offices that will become vacant August 1, 1931, was selected by the national nominating committee which met at Institute headquarters, New York, December 5, 1930. This committee consists of fifteen members, one selected by the executive committee of each of the ten geographical districts, and the remaining five elected by the board of directors from its own membership.

The following members of the committee were present: W. L. Amos, Toronto, Ont.; K. A. Auty, Chicago, Ill.; H. V. Carpenter, Pullman, Wash.; H. P. Charlesworth, New York, N. Y.; A. B. Cooper, Toronto, Ont.; Herbert S. Evans, Boulder, Colo; E. A. Hester, Pittsburgh, Pa. (alternate for E. C. Stone of Pittsburgh); H. A. Kidder, New York, N. Y.; E. B. Meyer, Newark, N. J.; J. S. Palmer, Kansas City, Mo.; W. S. Rodman, Charlottesville, Va. (alternate for E. D. Wood, of Louisville, Ky.); Harold B. Smith, Worcester, Mass.; C. E. Stephens, New York, N. Y.; R. G. Warner, New Haven, Conn.; W. L. Winter, San Francisco, Calif.; and F. L. Hutchinson, New York, N. Y., Secretary of the Committee. Past-president Harold B. Smith was elected chairman of the Committee.

The following is a list of the official candidates as selected by the committee:

For President

Charles E. Skinner, Assistant Director of Engineering, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

For Vice-Presidents

Middle Eastern District: W. B. Kouwenhoven, Professor of Electrical Engineering and Assistant Dean, School of Engineering, Johns Hopkins University, Baltimore, Maryland.

Southern District: W. E. Freeman, head, Department of Electrical Engineering, Assistant

Dean of College of Engineering, University of Kentucky, Lexington, Kentucky.

North Central District: Paul H. Patton, Telephon Engineering, Northwestern Bell Telephone Company, Omaha, Nebraska.

Pacific District: A. W. Copley, Engineering Manager, Pacific Coast District, Westinghouse Electric and Manufacturing Company, San Francisco, California.

Canada District: L. B. Chubbuck, Switching Equipment Engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada.

For Directors

L. W. Chubb, Director of Westinghouse Research Laboratories, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

B. D. Hull, Engineer, Southwestern Bell Telephone Company, Dallas, Texas.

H. R. Woodrow, Electrical Engineer, Brooklyn Edison Company, Brooklyn, New York.

For National Treasurer

W. I. Slichter, Professor of Electrical Engineering, Columbia University, New York, N. Y.

The Constitution and By-laws of the Institute provide that the nominations made by the national nominating committee shall be published in the January issue of the Institute Journal. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and By-laws:

Constitution

Sec. 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the National Secretary when and as provided in the By-Laws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

By-Laws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the Secretary of the National Nominating Committee not later than February 15 of each year, to be placed before that Committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the National Nominating Committee in accordance with Article VI of the Constitution and sent by the National Secretary to all qualified voters during the first week in March of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

National Nominating Committee
(*Signed*) By F. L. Hutchinson,
Secretary.

C. E. Skinner

Charles Edward Skinner, assistant director of engineering for the Westinghouse Electric & Manufacturing Co., a manager of the Institute (1915-19) and one of its vice-presidents (1919-20), was born on a farm near Redfield, Ohio, May 30, 1865. He was educated at Ohio University and Ohio State University, being graduated from the latter with an M. E. degree with the class of 1890. He worked his way through the university, partly as a helper at the Ohio Experimental Station Dairy and partly as a machinist in the university shops. In August, after graduating in June, he joined the organization of the Westinghouse Electric & Manufacturing Company as a machinist in charge of the manufacture of railway controllers. Early in 1891 he was put in charge of all insulation design, as well as testing. In addition to the insulation work, he took up magnetic testing and the development of magnetic materials in 1892, and retained charge of this work for many years.

In 1906 Dr. Skinner organized for the Westinghouse company the research division of the engineering department, and was responsible for the organization and equipment of the chemical, physical and process laboratories, as well as the high-tension test laboratory.

Through his efforts a laboratory for more fundamental research was determined upon in 1915 and he had charge of the building, equipping, and organization of the personnel of this laboratory. In 1920 he was made manager of the research department, taking direct and individual charge of the research laboratory for the next two years. In 1922 he was made assistant director of engineering.

Dr. Skinner went to Brussels in 1906 as American representative of the International Association for Testing Materials. In 1915 he was a special delegate from the A. I. E. E. to confer with the British Engineering Standards Committee. In 1920 he was chairman of the American Delegation to the Brussels meeting of the International Electrotechnical Commission, and held a similar position at the meeting of that commission in Geneva, Switzerland, in 1922. He was a member of the American delegation to the International Electrotechnical Commission meeting in London in 1924, The Hague in 1925, New York in 1926, and Bellagio in 1927. He was a delegate to the World Power Conference in London in 1924.

Dr. Skinner was chairman of the American Engineering Standards Committee the years of 1925, 1926, and 1927. He was elected chairman of the committee for the organization of the International Standards Association and represented the United States at the London conference of the I. S. A. in 1926.

Dr. Skinner was a member of the Engineering Council throughout its life, and is a member of the American Engineering Council, its successor. He was chairman of a special committee appointed by the Electrical Manufacturers Council, at the request of Herbert Hoover, then Secretary of Commerce, to work with the Department of Commerce and Bureau of Standards. He has been a member of the standards committee of the Institute for many years. As past chairman of the American Engineering Standards Committee he becomes a member of the board of directors of the American Standards Association.

Dr. Skinner is a Fellow of the American Institute of Electrical Engineers, member of the Franklin Institute, American Society for Testing Materials, Fellow of the American Association for the Advancement of Science, member of the American Society of Mechanical Engineers, member of the Engineers' Society of Western Pennsylvania, member of the National Electrical Manufacturers Association, the American Physical Society, the American Electrochemical Society, the Philosophical Society of Pittsburgh, th Engineers' Club of New York, the United States committee of the International Electrotechnical Commission, and the University Club of Pittsburgh. He was appointed a delegate to the International Engineering Congress held in Japan in October, 1929, acting as chairman of the American Electrochemical Society's delegation and a member of the American Standards Association's delegation to th congress. In 1927 he received the honorary degree of Doctor of Science from Ohio University.

In addition to those already mentioned Mr. Skinner has served on the following committees of the Institute: Edison medal, executive, public policy, principles of professional conduct, meetings and papers, research, electrical machinery, educational, and electrophysics.

W. B. Kouwenhoven

William Bennett Kouwenhoven was born at Brooklyn, N. Y., January 13, 1886. He received his early education at the Polytechnic Institute of Brooklyn and was graduated with the Degree of E. E. *cum laude* in 1906 and a year later received the degree of M. E. from the same institution. Early educational experience was obtained acting as instructor in electrical engineering at the Polytechnic Institute of Brooklyn for four years subsequent to his graduation. The next three years were devoted to study in Germany under Professor Arnold at the Karlsruhe Technische Hochschule, Baden, Germany, where the Degree of Doktor Ingenieur *magna cum* was conferred on him in 1913.

During the course of Prof. Kouwenhoven's professional career, he has been known to be an able educator, diligent research worker and a very capable engineer. In addition to the foregoing educational experience, he served for a year as instructor in electrical engineering at Washington University and in the year 1914 was appointed an instructor in electrical engineering at Johns Hopkins University and to date is connected with the latter institution. His progress was rapid and during the year 1917 he was promoted to the rank of associate in electrical engineering, in 1919 he was promoted again, to the rank of associate professor, and in 1930 he was made professor of electrical engineering and assistant dean of the engineering school.

Professor Kouwenhoven was in charge of the electrical engineering department at Johns Hopkins University and acted as instructor in the Reserve Officers Training Corps unit and held the rank of Captain during the war. He served part-time acting as a consulting electrical engineer at the Bureau of Standards.

From 1919 to 1920, while on leave from Johns Hopkins University, he was master engineer in the employ of the Winchester Repeating Arms Company and in charge of the installation of a plant for the manufacture of batteries and flashlights.

Professor Kouwenhoven has been very active in the Institute and other engineering societies. He became an Associate of the Institute in 1906 and was transferred to the grade of Member in 1922. He has been a member of the following Institute committees: communication, electrophysics, instruments and measurements, Sections, and the committee on coordination of institute activities. For the past three years he served as chairman of the sections committee and at present he is chairman of the Baltimore Section.

In addition to his Institute activities, many noteworthy publications, too numerous to enumerate, along research lines and on the subject of instruments and measurements, have been credited to his name. Professor Kouwenhoven is a member of the A. S. T. M. and has served as vice-chairman of the committee on magnetic testing. He is also a member of the Johns Hopkins Club and the Baltimore Engineers Club.

W. E. Freeman

William Edward Freeman was born in Fayette County, Ky., September 25, 1880. After obtaining his early education in the schools of Fayette County he attended Transylvania College and received his A. B. Degree in 1901. Technical education was obtained at the University of Kentucky, where he received the degree of B. M. E. in 1904 and later, in the year 1912, an E. E. degree was conferred on him.

Additional technical training by taking the apprentice course while in the employ of the Western Electric Company was obtained after he had received his B. M. E. degree from the University of Kentucky. The first years of his experience were obtained in the shops and the drafting department at the Chicago plant, which were followed by five and one-half years work on engineering telephone apparatus design in Chicago and in the Bell Laboratories at New York. With his good technical background and very capable manner, a number of pieces of communication apparatus were developed by Mr. Freeman during the course of his work.

In 1911 he left the engineering department of the Western Electric Company to take a position as head of the electrical engineering department at the University of Kentucky. There he was known to be a capable educator and all who had contact with him, both students and associates, benefited by this contact and his friendship. From May, 1920, to August, 1921, he supervised commercial training with the Westinghouse Electric & Manufacturing Company and during the following year acted as dean of the Engineering college at the University of Kentucky. In 1922 he was made assistant dean of the college of engineering and head of the department of electrical engineering at that university and to date is affiliated with the same institution in the same capacities.

Professor Freeman became an Associate of the Institute in 1911 and was transferred to the grade of Member in 1926, and at present he is the Branch counselor at the University of Kentucky. He is a member of the S. P. E. E. and a past-president of its Kentucky Section, a member of Kappa Alpha, Tau Beta Pi, Lamp and Cross, Masons, and Rotary Club. He is now president of the Lexington Rotary Club.

P. H. Patton

Paul Harsha Patton was born October 3, 1873, at Harshaville, Ohio. His early education was obtained at the schools in Denver and through his perseverance and initiative his technical aspect was broadened by intensive study and reading, a large part of which was night work.

Broad and varied experience was obtained in the communication field and Mr. Patton has devoted many years of work in the testing, installation, operating and management of communication companies. His career began as a telephone installer and test man in Denver in the year 1891, followed by ten years of maintenance and installation experience of multiple switchboards. Part of the time was devoted to lighting and power systems of central offices, toll switching, party line ringing and simplex telegraph and phantom equipment. In 1903 he served as superintendent of the fire and police telegraph systems and as chief inspector for enforcement of the National Electric Code, as well as supervising street lighting in the city of Omaha. During the following year he served as general superintendent of the U. S. Telephone and Telegraph Company, Waterloo, Iowa.

In 1905 he became general equipment foreman of the Nebraska Telephone Company and later was appraisal engineer, serving on the Nebraska State Railway Communication Committee for the Development of Telephone Plant Cost Units. In 1909 he became division engineer in responsible charge of engineering plans, specifications and estimates for all types of telephone plants. He was a member and treasurer of the Omaha and Council Bluffs electrolysis survey committee, a director, vice-president and president of the Omaha Technical Club, as well as a member and secretary of the Nebraska Joint Committee on Physical Relations between Electrical Supply and Signal Lines.

Mr. Patton was a member of the organization committee of the Engineers' Club of Omaha when it was organized in 1923, and has been active in the work of the club since that time, serving it in the capacities of member, director, treasurer, and president.

Mr. Patton became an Associate of the Institute in 1918 and was transferred to the grade of Member in 1925. He was a member of the formation committee for the organization of the Nebraska Section of the A. I. E. E. His long, continuous service with the telephone company, together with his joint work and many other activities, has made him a prominent figure in the communication field.

A. W. Copley

Almon Warren Copley was born in Clay Center, Kansas, January 13, 1883. Immediately after completing his electrical engineering course at the University of Kansas he entered the employ of the Westinghouse Electric & Manufacturing Company as an engineering apprentice at East Pittsburgh, Pa., and he has been in the service of that company continuously since that time.

During the course of his professional career, Mr. Copley obtained broad engineering experience. In particular, his prominent work in power transmission and inductive interference in connection with railway electrification has made him one of the recognized leaders in this subject among the engineers of the country. His other experiences consisted chiefly of designing instruments, watthour meters, relays and other similar devices. In 1913 he was in charge of designing automobile starting, lighting, and ignition equipment.

Because of his excellent character and ability, his advancement in the engineering field was unusually rapid. In 1915 he became general engineer, dealing particularly with special problems on railway electrification and general power and distribution systems. In 1921 he was made general engineer for the Pacific Coast and in 1925 he became manager of the engineering division of the San Francisco Office, dealing with engineering in all classes of electric apparatus. In 1928, upon the formation of the Pacific Coast district of the company, he was made engineering manager for the district.

Mr. Copley became an Associate member of the Institute in 1904 and was transferred to the grade of Fellow in 1926. He has ably served on the communication committee as well as on the committee on power transmission and distribution. He has been active in Institute affairs and is well known to the membership. In addition to his Institute activities he is also a member of the Pacific Coast Electrical Association, the Engineers' Club of San Francisco, and the University Club of Pittsburgh.

L. B. Chubbuck

Leonard Burrows Chubbuck was born in Ottawa, Canada, and received his college education at the University of Toronto. He took his B. A. Sc. degree in 1900 and E. E. degree shortly afterward.

Immediately after graduation he entered the employ of the Westinghouse Electric & Manufacturing Company at East Pittsburgh, first in the drafting office and later in the power division of the engineering department. His work included switching equipment design, starting from the early days of air and oil circuit breakers.

In 1909, after nine years' experience with the Westinghouse Electric & Manufacturing Company he was transferred to the Canadian Westinghouse Company at Hamilton, Ontario, where he has been in charge of the engineering department section handling switching equipment, control, circuit breakers, etc. His first work in Canada comprised the Westinghouse switching equipment for the first stations of the Ontario Hydro Electric Commission when 110,000-volt equipment was designed and installed with very great respect. Since that time Mr. Chubbuck has been intimately connected with the switching equipment design of most of the later large hydroelectric plants throughout Canada. He has taken out various patents on disconnecting switches, etc.

Mr. Chubbuck was an Associate of the Institute for the periods 1902-1909 and 1918-1926 at which time he was transferred to the grade of Member. He has served as chairman of the Toronto Section, was Section delegate to the Chicago and to the White Sulphur Springs conventions of the A. I. E. E. and was a member for some years of the committee on protective devices.

Various engineering articles by Mr. Chubbuck have been published in the *Electric Journal*, *Electrical News*, etc., and he has lectured before the Engineering Institute of Canada, Canadian Electrical Association and Toronto Section of the A. I. E. E. He is much interested in sports and is a past president of the Burlington and of the Hamilton Tennis Clubs.

L. W. Chubb

L. Warrington Chubb, son of the late Col. Chas. St. J. Chubb, was born in Fort Yates, Dakota, on October 22, 1882. He obtained his common school education at Cheyenne, Wyoming, and Columbus, Ohio. In 1901, he entered Ohio State University and four years later was graduated with the degree of M. E. in E. E. In 1905, he entered the employ of the Westinghouse Electric & Manufacturing Company at East Pittsburgh, as an engineering apprentice. In 1909, he was engaged in the development and application of magnetic materials. Before the organization of an isolated research department at the Westinghouse company he had charge of advance development work on electrotechnical problems and new developments.

Mr. Chubb has been very active in standardization, both national and international, and in committee work of the leading technical societies. Twice he has been sent to London and Brussels as a delegate of the International Electrotechnical Commission. His wide experience in many pioneer fields of development work has resulted in his being awarded about two hundred patents in electrical, mechanical, chemical and electrochemical and welding fields, and for various types of instruments.

In 1920, when the Westinghouse company organized its radio engineering department, Mr. Chubb was appointed manager of that department. He continued in that capacity until Jan. 1, 1930, when the radio activities of the Westinghouse and General Electric companies and the Radio Corporation of America were consolidated and concentrated at Camden, New Jersey, at which time he was appointed assistant vice-president of engineering. In June, 1930, he returned to East Pittsburgh as Director of the Westinghouse Research Laboratories.

He has been active in the Institute for more than twenty years and presented numerous papers before its meetings. He also is a member of the National Electric Light Association, American Railway Association, International Electrotechnical Commission, American Standards Association, Illuminating Engineering Society, American Association for the Advancement of Science, American Physical Society, and the Franklin Institute of Pennsylvania.

B. D. Hull

Blake D. Hull was born in Galesburg, Michigan, September 12, 1882, and moved to Kansas at an early age. He received his grade and preparatory education at Delphos, Kansas and graduated from the University of Kansas in 1905 with the degree of B. S. in Electrical Engineering. Since that date he has been in the employ of the Southwestern Bell Telephone Company in various branches of engineering work. At the present time he is chief engineer for that company for the state of Texas. He is past vice-president of the seventh geographical district of the Institute. He is first vice-president of the Dallas Technical Club and President of the Dallas Electrical Club. He is a member of the Institute of Radio Engineers. In addition to his business and technical activities he is a member of the Dallas Country Club, a Mason, and a member of the diaconal of the Highland Park Presbyterian Church.

H. R. Woodrow

Harry Roy Woodrow was born in Luverne, Minnesota, April 15, 1887. After finishing his elementary school training in Des Moines, Iowa, he entered Drake University and graduated with the degree of B. S. in 1909. He continued his education at the University of Illinois under a scholarship and received the degree of M. S. with physics as major in 1911.

Mr. Woodrow joined the electrical engineering staff of The New York Edison Company in 1911 and continued his work with that organization until 1920, having advanced during the period to the position of assistant electrical engineer. During 1921 and 1922 he was in engineering work with Stone & Webster, Inc., and the Westinghouse Electric & Manufacturing Company.

During 1922 Mr. Woodrow joined the staff of the Brooklyn Edison Company in the position of assistant electrical engineer and still is with that organization, now occupying the position of electrical engineer.

Mr. Woodrow is a Fellow of the Institute and a member of the National Electric Light Association and has held the following positions in the engineering activity of these two organizations:

Chairman of the protective devices committee, A. I. E. E., 1921-25; chairman of the committee on transmission and distribution, A. I. E. E., 1928-30; chairman of the electrical apparatus committee, N. E. L. A., 1927; member of the executive committee of the Engineering Section, N. E. L. A., 1928-29; chairman of the sectional committee on lightning arresters, American Standards Committee, 1924; member of the committee on electricity distribution and use, Assoc. of Edison Illuminating Companies, 1924-25; member of the committee on electric switching and switchgear, Assoc. of Edison Illuminating Companies, 1929-30.

Mr. Woodrow holds a number of patents on electrical connections and devices. He is a member of Phi Beta Kappa, Sigma Psi and Tau Psi fraternities and a member of the Engineers Club of New York and the Crescent Club of Brooklyn.

Walter I. Slichter

Walter Irvine Slichter was born in St. Paul, Minnesota, May 7, 1873, and was graduated at Columbia University in 1896 with an E. E. degree.

He entered the employ of the General Electric Company as a student in July, 1896, and the following year was transferred to the office of Dr. C. P. Steinmetz, where he was engaged for a year in carrying on experimental work, tests and calculations on various subjects. During the following two years, he was engaged in designing induction motors, alternators, rotary converters, transformers and special experimental apparatus. For a number of years thereafter he devoted most of his time to the design of electrical machinery and, more particularly, the equipment of electric railways.

In 1910, he was appointed professor of electrical engineering and head of that department at Columbia University, which position he still fills.

During the war he was civilian director of the Air Service school for radio officers at Columbia University. Since 1914, Professor Slichter has devoted considerable time to instruction in electrical engineering to naval officers of the postgraduate school of the U. S. Navy, who are detailed for study at Columbia University.

Professor Slichter became an associate in the Institute in 1900 and was transferred to the grade of Fellow in 1912. He was a member of the board of directors from 1918 to 1922, vice-president from 1922 and 1924, and has been an active worker upon several of the important committees of the Institute. He has been chairman of the meetings and papers committee, of the editing committee, and a member of the finance committee. He is a member of several other engineering and scientific societies, and in 1903 was president of the General Electric Engineering Society, and was instrumental in reorganizing it into the Schenectady Section of the Institute. He also served for several years as treasurer of the Society of Engineers of Eastern New York.

Professor Slichter has presented several papers and discussions upon various engineering subjects before the Institute and other societies, and has published many articles on technical subjects.

◆ ◆ ◆

Louisville Discussions Summarized in Review

Only discussion submitted in writing in accordance with A. I. E. E. rules governing it, is summarized; complete discussion, together with all papers so approved, will be published in the Transactions. A list of papers presented was published in the November issue of the Journal:

Session on Transmission and Distribution

J. J. Torok discussed "LIGHTNING INVESTIGATION AT ALCOA, TENNESSEE." He pointed out wherein the results obtained at Alcoa, coupled with data from other investigations, aided considerably in establishing a more consistent concept of the origin and manner in which surges appear on the line. He cited that the results obtained bore strong evidence against the induced-voltage theory. Of the hundreds of strokes appearing over or near the line only one or two resulted in a surge which might be harmful in its character. Oscillograms of these surges showed them to be of long duration, 30 to several hundred microseconds instead of one or two to 15 or 20 microseconds, as was the earlier belief. Calculations made from these and other records as a basis determined the probable magnitude of induced surges to be of the order of from 100,000 to 200,000 volts, a value harmless to high-voltage transmission lines. Results bear out the prominence of the direct-strike theory with the need for adequate ground wire protection and low tower and footing resistances.

Records kept by these experimental stations in Tennessee showed that a normal switching surge will seldom exceed three times normal and only rarely rise to four times normal. Such data on switching surges are of great value in that they will indicate the minimum insulation a transmission line can have and still give good operating records.

J. B. MacNeill discussed the statement in E. E. George's paper, "Potential transformers are the best and most economical form of potential supply in the long run." He pointed out that successful operation on many large systems, including relaying, indicated the worth of bushing potential devices when used within their ratings. Low Costs and elimination of high-voltage potential transformers justify their use when possible. Mr. MacNeill explained further that recent improvements in bushing potential devices have reduced phase-angle error considerably over a wide voltage range.

Session on Protective Devices

A discussion submitted by Doctor Wilhelm Lampert on "THE PHYSICAL NATURE OF NEUTRAL INSTABILITY" was read by A. E. Knowlton. Doctor Lampert stated that at frequencies with ratios which compared with the impressed frequency is *not* an integer, an alternating bias is necessary. At even harmonics the ratio of which *is* an integer of the fundamental frequency a bias is not at all necessary. These cases are analyzed in his discussion.

John Auchincloss discussed the effect in practical cases of the neutral phenomena described in the papers on "Y-CONNECTED POTENTIAL TRANSFORMERS." The occurrence of the neutral phenomena described may give rise to very misleading or false conclusions in attempting to interpret certain system conditions from the readings of instruments connected to Y-connected potential transformers. These involve the phase comparison of system voltages for purposes of synchronizing across grounded Y-delta power transformer banks, and the detection of accidental grounds on isolated-neutral systems operating at voltages beyond the range of the ordinary electrostatic ground detector.

Professor Walter L. Upson discussed "THEORY OF ABNORMAL LINE-TO-NEUTRAL TRANSFORMER VOLTAGES." He commented on the different methods of attack in the three companion papers and analyzed Mr. La Pierre's equivalent-circuit phenomena. He believes Mr. La Pierre's theory is no doubt correct and that it is greatly clarified in the last section of the appendix. He calls attention to the lack of directions here which would enable one to predict the type of oscillations which might be expected. A series of actual oscillograms based upon predetermined constants and conditions would be interesting.

W. W. Edson in his discussion inquired about the effect of "NEUTRAL INSTABILITY," or the half- and double-frequency oscillations, on certain installations. One of these installations is three 8050/115-volt star-delta-connected potential transformers operating watthour and power-factor meters. Another was the same installation as above only operating directional relays instead of watthour and power-factor meters.

F. A. Hamilton's discussion of the papers by Messrs. C. T. Weller, C. W. La Pierre, A. Boyajian and O. P. McCarty was read by C. J. Schaus. In addition to the experiences with two applications of grounded-neutral potential transformers on portions of systems necessarily operated underground at certain times described in Mr. Weller's paper, Mr. Hamilton called attention to several other similar cases of the phenomena.

Discussion by J. Fallon on the Physical Nature of Neutral Instability was read by J. J. Thalheimer.

W. W. Edson discussed "POWER TRANSFORMER NOISE—ITS CHARACTERISTICS AND REDUCTION" with particular reference to installations adjacent to a building in residential districts. He suggested placing the transformers in a pit in front of the building. The noise would be reflected upward and would not even be objectionable to residents across the street.

In connection with discussion on "POWER TRANSFORMER NOISE," Sol Naiman suggested that a paper be prepared on the elimination of noise in small motors used for hospital installations.

F. W. Gay discussed "POWER TRANSFORMER NOISE" and suggested several methods for its reduction with a resulting improvement in apparatus design. One method suggests the lowering of densities at which materials are operating during light-load periods by the use of transformer windings in series during those periods, and in multiple during heavy-load periods. Another method of eliminating noise would be to fully enclose the electrical equipment in noise-proof compartments and carry off the heat at several different temperatures by using bodies of volatile fluid each separately sealed.

Session on Power Generation

T. E. Purcell discussed "GOVERNOR PERFORMANCE DURING SYSTEM DISTURBANCES." He cited that tests conducted under his supervision which were reported in a paper entitled "Operating Characteristics of Turbine Governors," presented at the 1930 A. I. E. E. Winter Convention, bore out the same general results as those reported in this paper.

He expressed surprise in finding out that turbines under test, overspeed enough to trip the emergency governors when loads in excess of 60 per cent of the rated capacity were dropped. He referred to recent tests on a 60,000-kw. single-cylinder turbine newly installed. The maximum load of about 70,000 kw. can be suddenly dropped by opening the generator oil circuit breaker without tripping the emergency governor.

E. E. George discussed "GOVERNOR PERFORMANCE DURING SYSTEM DISTURBANCES." He emphasized the importance of the point in the paper about getting machines back into step without taking them off the bus. This results in the saving of time required for re-synchronizing which might be excessive if there is trouble on the system.

Philip Sporn discussed "GOVERNOR PERFORMANCE DURING SYSTEM DISTURBANCES." He pointed out that during a system disturbance the amount of disturbance contributed by the governor itself toward the total disturbance cannot yet be definitely determined.

S. L. Henderson discussed "APPLICATION OF HYDROGEN COOLING TO TURBINE GENERATORS." He pointed out that there is some question whether it is necessary to build these machines explosive-proof. This question can only be answered by experience. He cited that the arrangement of coolers within the confines of the machine would be of interest as the machine is complete in itself and does not require the addition of ducts or cooler supports.

Directors Hold December Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Thursday, December 4, 1930.

There were present: President W. S. Lee, Charlotte, N. C.—Past President Harold B. Smith, Worcester, Mass.—Vice-Presidents Herbert S. Evans, Boulder, Colo.; W. S. Rodman, Charlottesville, Va.; C. E. Sisson, Toronto, Ont.; H. V. Carpenter, Pullman, Wash.; I. E. Moultrop, Boston, Mass.; H. P. Charlesworth, New York, N. Y.—Directors F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; C. E. Stephens, New York, N. Y.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.—National Treasurer W. J. Slichter and National Secretary F. L. Hutchinson, New York, N. Y. Present by invitation: H. A. Kidder, New York, Chairman of the Committee on the Engineering Profession.

Reports of meetings of the Board of Examiners held October 21 and November 18 were presented and the actions taken at those meetings approved. Upon the recommendation of the Board of Examiners, the following actions were taken upon pending applications: 1029 Students were enrolled; 70 applicants were admitted to the grade of Associate; 17 applicants were elected to the grade of Member; 69 applicants were transferred to the grade of Member; 9 applicants were transferred to the grade of Fellow.

Approval by the Finance Committee, for payment, of monthly bills amounting to $26,078.21, was ratified.

A resolution was adopted setting the time and location of the 1931 Annual Meeting of the Institute; namely, Monday, June 22, at Asheville, N. C., during the Annual Summer Convention of the Institute.

Mr. William B. Jackson was reappointed a representative of the Institute on the Engineering Societies Library Board for the four-year term beginning January 1, 1931. Mr. L. T. Robinson was reappointed a representative to serve on the Standards Council of the American Standards Association for the three-year term beginning January 1, 1931, and Messrs. H. H. Henline, H. M. Hobart, and H. S. Osborne were reappointed alternates on the Standards Council for the year 1931.

Approval was given of a plan developed by a joint committee of the Founder Societies and the McGraw-Hill Book Company for the publication by the latter of a series of Engineering Societies Monographs, consisting of manuscripts worthy of publication which have been submitted to the societies but which will not be published by the societies. Messrs. E. B. Meyer and W. I. Slichter were appointed as the Institute's representatives on the Engineering Societies Monographs Committee.

Other matters were discussed, reference to which may be found in this and future issues of the Journal.

◆

A Half Century of Electrical Engineering

In celebration of its fiftieth anniversary, the Western Society of Engineers held a meeting in Pittsburgh, Pa., November 14, at which the progress of engineering achievement during the life of the Society was the keynote of the addresses delivered.

Professor Charles F. Scott, Yale University, covered the field of electrical engineering, describing its major advances step by step, from the advent of engine power in the last century to the outstanding electrical developments of today. With the birth of engine power, the engineering spirit was awakened and in two decades the half dozen engineering schools of 1860 had increased fourscore; yet the engineers of 1880 little realized that a new power would soon be at their service.

The Edison incandescent lamp, announced in 1879, inaugurated the era of electric service which has become almost universal—a second industrial revolution. In 1886 the a-c. system of distribution, sponsored by George Westinghouse, began operation in Buffalo, and with it came the era of long distance transmission.

In the sixties the general communication system with numerous private lines connecting residences, offices, and factories, established a service for person-to-person communication carried on by messenger, printing telegraph, and delivery boy. This system was simplified by invention and about 1878 the telephone exchange was installed. Thirty years ago Marconi's three dots spanning the Atlantic heralded the wireless telegraph. Then came broadcasting. A new public service was inaugurated in the pioneer broadcasting which took place about ten years ago. Frank Conrad working with the amateurs discovered that the rejected short wave had vast superiority for long distance service; for instance, talking with Byrd at the South Pole.

One may well ponder over the question —Does electric power, or electric communication—one serving the physical, the other intellectual—make the greater contribution to our modern life?

In the advance of man, definite stages or epochs are recognized. The use of fire, the bow and arrow, the invention of pottery, the domestication of animals, the use of iron—each gave means of life on a higher plane. The outstanding factor in historic time is the production of power; in plotting a curve of human progress the long level of many centuries changes into high ground as the activities of the 19th century of steam power are reached. But they are only foothills before the rising altitude of the 20th century record. These curves of activity in a score of fields, simultaneously with the shift from muscle to manufactured power, coincide with the increasing use of power in the new ways provided by electricity.

In achievement and in anticipation, the story of electricity during the past half century illuminates the verdict of Herbert Hoover that "Electricity is the greatest tool that ever came into the hands of man."

◆

Treasurer Hamilton Resigns W. I. Slichter Elected

National Treasurer George A. Hamilton, because of illness, has found it necessary to resign his office. With regret, on November 25th, at a special meeting of the Executive Committee the resignation was accepted and Professor Walter I. Slichter of Columbia University was elected to fill the unexpired term ending July 31, 1931.

At a meeting of the Board of Directors held December 4, the action of the Executive Committee was ratified and the following resolution adopted:

> Whereas the resignation of National Treasurer George A. Hamilton, because of illness, was accepted with regret by the Executive Committee at a special meeting held at Institute headquarters on November 25, 1930, and this action has been confirmed at this meeting, be it
>
> Resolved that this Board, acting in behalf of the membership of the Institute, hereby places upon record its high appreciation of Mr. Hamilton's long and loyal service since 1895, as Treasurer of the Institute; also of his many and valuable contributions to the Institute as a charter member, Vice-President 1884-6, and member of the Board of Directors, Executive, Edison Medal and other committees; and extends to Mr. Hamilton its greetings and best wishes.

Memorable Meeting Held by the A. S. M. E.

So many features of the annual meeting of the American Society of Mechanical Engineers held early in December were of technical interest and stimulus that its fruitfulness will no doubt be felt well into the future. Good papers of ample scope in the fields to which they specifically applied were supplemented by the animated general discussion which always makes so strongly for constructive values. The handling of materials, railroad development, machine shop practise, gas and oil power, central station power, aeronautics, refrigeration, and American management in Europe, were a few of the subjects to which the convention gave investigation and with more than two thousand engineers in attendance one may appreciate its significance as a medium for the dissemination of a superabundance of broad and versatile information. Industrial accident prevention was supported in a symposium given under the auspices of the A. S. M. E. standing committee on safety.

In a session on hydraulics, Frank E. Bonner, executive secretary of the Federal water-power commission gave rise to such enthusiasm and support of his cause that a resolution was passed by the society's Council for the appointment of a special "Engineer's Water-Power Policy" committee, on which would serve five men chosen from the national representative bodies—two from American Engineering Council and one each from the mechanical, civil, and electrical engineers. The essence of Mr. Bonner's paper appears elsewhere in this issue.

"The Human Problem" took issue in an address delivered by Professor Elliott Dunlap Smith of Yale, at the annual dinner. It was a challenge to the engineer's unmindfulness of obligation both social and technological, and the animation with which Professor Smith delivered his speech paved the way forcefully for sessions held for the discussion of the stabilization of employment, and of economic and industrial power. A special conference assembled at the request of American Engineering Council presented Colonel Arthur S. Wood, chairman of the President Hoover Emergency Committee for Employment to sponsor industry's efforts to stabilize employment both in the past and during the present crisis. In his address he cited a paper presented in 1886 by Henry R. Towne—an epoch-making document responsible for the inauguration of an entirely new management movement in this country. The greatest hope of solution for the present crisis, Colonel Wood believes, rests with an intelligent and persistent attack of the situation by engineers and economists.

Account of the award of the John Fritz Gold Medal to Admiral David Watson Taylor, Chief Constructor of the United States Navy during the World War, and the conferring of honorary membership in the Society upon Doctor Elihu Thomson, past-president of the Institute, may be found briefly stated in another news column of this issue.

Section delegates, the representatives of localized and important society effort, were also in special convention at this last annual meeting, which has also been voted "the best."

◆

Illumination Commission to Meet in England

President E. C. Crittenden of the U. S. national committee of the International Commission on Illumination reports that the general outline of plans for the session to be held in Great Britain in 1931 is now practically complete. In connection with the commission's sessions there will be an international illumination congress and a tour of inspection to various cities. The whole program will fill the time from Sept. 2 to Sept. 19, 1931.

After registration in London delegates will go to Glasgow for the first session Sept. 4. Meetings will follow in Edinburgh, (Sept. 6), Sheffield, (Sept. 8), Birmingham, (Sept. 10), and finally in Cambridge, (Sept. 13-19). The dates have been chosen to bring the meetings to a close immediately before the three-day celebration of the Faraday centennial in London, which will include a meeting of the Institution of Electrical Engineers and will be followed by the annual meeting of the British Association for the Advancement of Science.

Looking forward to the 1931 sessions, the primary aim of the U. S. committee during the past year has been to arrange for creditable representation at the sessions of American interests,—developments, and opinions. The United States is particularly charged with responsibility for four very important divisions of the commission's work: (1) motor-vehicle lighting, (2) factory and school lighting, (3) aviation lighting, and (4) applied lighting practise in fields not otherwise specifically covered. The last two are new assignments, and in these there has been the keenest interest.

To provide a direct connection between the four committees in charge, a special committee has been formed under the chairmanship of A. L. Powell. This coordinating committee is to assist and advise also those who represent the United States on the 14 projects managed by other national committees, thus serving as a general clearing house for American contributions to the congress and commission sessions outside the scope of the secretariat committees.

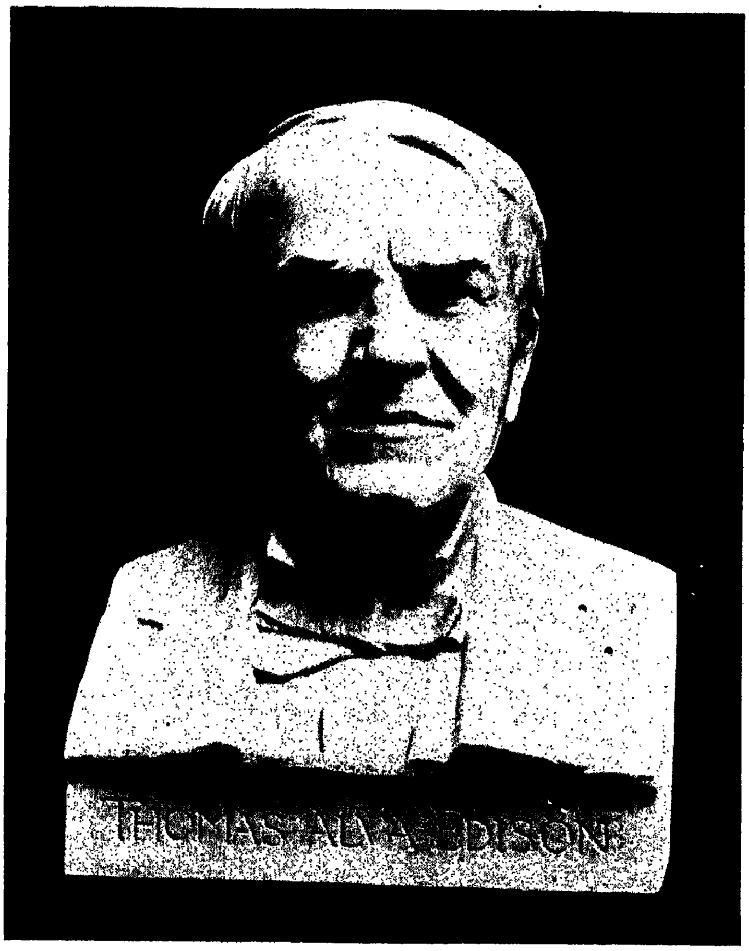
On two important questions of standardization the assistance of this commission has been sought during the year by other international organizations. One is the problem of lamp bases and sockets; this has been before the International Electrotechnical Commission for several years.

The second question of international standardization which has been raised falls clearly within the field of the I. C. I. The International committee of weights and measures, which now has jurisdiction over international electrical units and standards, has taken up the problems of photometry also. Its advisory committee on electricity has been authorized to seek the collaboration of the I. C. I.; this action will give a new stimulus to the attempt to agree upon (1) a primary standard of light and (2) a uniform and accepted method of measuring lights of widely diverse colors.

Reverting to the matter of representation from this country at the 1931 session, it should be made clear that participation in the session and the tour of inspection is not limited to those who are now taking part in the work of the Committee. The A. I. E. E. is represented on the U. S. National Committee by A. E. Kennelly, C. O. Mailloux and Clayton H. Sharp.

◆ ◆ ◆

Edison Bust for Deutsches Museum



The Hall of Honor in the Deutsches Museum, Munich, shortly will receive from the United States, with the Institute and the Edison Pioneers as joint sponsors, a marble bust of heroic size of Thomas A. Edison. Formal presentation will be made in Munich by an American delegation, the date of presentation being subject to the convenience of the museum authorities.

District Prizes Awarded at Philadelphia Meeting

J. A. Noertker, of the Cincinnati Street Railway Company's engineering department, and H. F. L. J. Seyler of the Consolidated Gas Electric Light and Power Company of Baltimore, are winners respectively of the Institute's Best Paper Prize and the Initial Paper Prize awards for the year 1929. Mr. Noertker's paper was entitled *Street Railway Power Economics on the Cincinnati System*, and Mr. Seyler's, *Current Characteristics of Constant-Current Transformers During Sudden Changes of Load.* Awards were made October 14, 1930, at the Institute's Middle Eastern District Meeting at Philadelphia.

J. A. NOERTKER

Mr. Noertker is a native of Cincinnati, Ohio, and a graduate of the University of Cincinnati (1928). He entered the employ of the Cincinnati Traction Company as a cooperative student, and after graduation remained with the company in the capacity of "special engineer." In 1927 he was promoted to the position of electrical engineer of the newly organized Cincinnati Street Railway Company.

H. F. L. J. SEYLER

Mr. Seyler is a graduate of York High School, York, Pennsylvania (1923) now doing night school work at Johns Hopkins for a B. S. degree in engineering. He has traveled extensively in this country in the interest of the electric construction department of the Pennsylvania Water and Power Company. Since 1925 he has been in the electric test department of the Consolidated Gas, Electric Light and Power Company engaged in various special tests and investigations on radio interference problems, special studies on constant-current transformers, and series street-lighting circuits; also the effects of corona on fuses, and the characteristics of high-voltage fuses, disconnect switches, oil circuit breakers, etc. Most of his time is now being devoted to special oscillographic work and a generalized study of lightning on the 66-kv. ring of the Consolidated company.

◆ ◆ ◆

Edison Medal Awarded to Dr. Frank Conrad

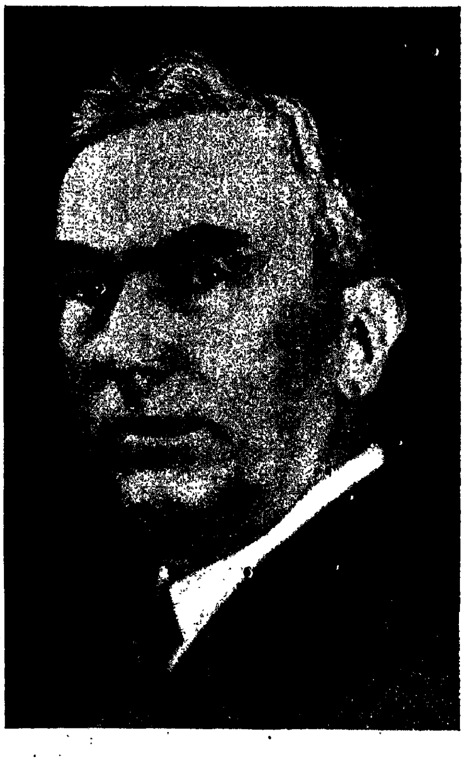
"FOR his contribution to radio broadcasting and short-wave radio transmission" Doctor Frank Conrad, Pittsburgh, Pa., has been given the 1930 Edison Medal Award by the American Institute of Electrical Engineers. It is planned to present the medal to Doctor Conrad on Wednesday evening January 28, 1931, in connection with the annual Winter Convention of the Institute.

The Edison Medal was founded February 11, 1904, by associates and friends of Thomas A. Edison and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts," by a committee consisting of twenty-four members of the Institute.

Since its establishment the medal has been awarded to the following men: Elihu Thomson (1909), Frank J. Sprague (1910), George Westinghouse (1911), William Stanley (1912), Charles F. Brush (1913), Alexander Graham Bell (1914), Nikola Tesla (1916), John J. Carty (1917), Benjamin G. Lamme (1918), W. L. R. Emmet (1919), Michael I. Pupin (1920), Cummings C. Chesney (1921), Robert A. Millikan (1922), John W. Lieb (1923), John W. Howell (1924), Harris J. Ryan (1925), William D. Coolidge (1927), Frank B. Jewett (1928), Charles F. Scott (1929).

Doctor Conrad was born in 1874 in Pittsburgh, Pennsylvania. In 1890 he entered the employ of the Westinghouse Electric and Manufacturing Company in Pittsburgh and his rise in that organization was rapid. After several years as an assistant in the shops he entered the laboratory and during the ensuing stage of his work he invented several forms of switches, lightning arresters, and breakers for use in alternating-current work. He was closely associated with, and later in entire charge of, the arc-lamp design department. This was his first engineering work. Doctor Conrad's connection with radio dates back before the days of broadcasting when he became interested as an amateur in radio reception of time signals and later in radio-telephone transmission by means of vacuum tubes. He established an amateur radio telephone station which later resulted in the development of the Westinghouse station, KDKA.

Doctor Conrad was appointed a general engineer of the Westinghouse organization in 1904 and was promoted to the position of assistant chief engineer in 1921. In 1925 he was awarded the Morris Liebmann Memorial Prize of the Institute of Radio Engineers for his early work in connection with high-frequency transmission.



DOCTOR FRANK CONRAD

He is a Fellow of the Institute of Radio Engineers, a member of the Society of

Automotive Engineers, and a member of the American Association for the Advancement of Science. He received the honorary degree of Doctor of Science in 1928 from the University of Pittsburgh.

◆

Conductivity of Threaded Connections

Measurements have been completed by the Bureau of Standards covering electrical resistance between nuts and bolts, using two radically different types of threads—the American National and the Dardelet—and different materials. Results showed that the contact resistance usually is less than the resistance of a one-inch length of the bolt and that under similar conditions the resistance of the Dardelet thread generally is not more than one-fourth that of the American National thread. Maximum resistances found were for steel bolts of the American National thread, in which, with a stress of 2,000 lb. per sq. in. in the bolts, (about an inch length of bolt), the resistance is about 10 microhms. Minimum stresses were found for copper bolts with Dardelet threads in which, with a stress of 6,000 lb. or more per sq. in., the resistance was approximately 0.02 microhm, equivalent to about 1/64 in. of bolt.

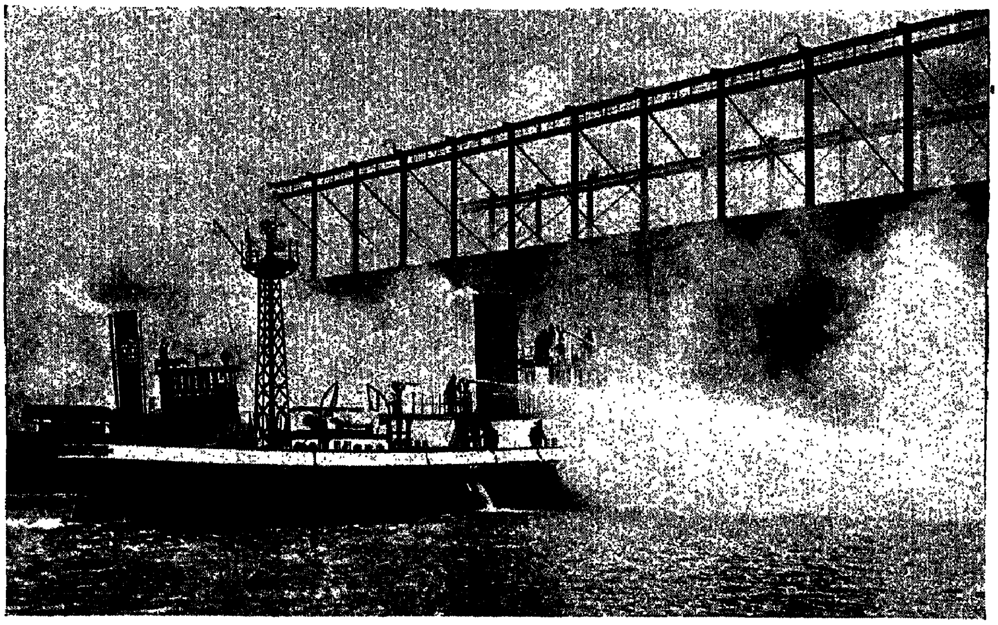
This subject is treated in further detail in Research Paper No. 227, Bureau of Standards.

◆

Dr. Millikan Predicts Added use of Sun's Rays

Science, instead of being even a fractional deterrant to business, as some claim, may prove on the contrary a solution whereby adjustment of present circumstances may be accomplished, is the opinion expressed by Doctor Robert A. Millikan before the second session of the Association of Life Insurance Presidents recently reported convention in New York City. Doctor Millikan's thought according to the account is to use direct sunlight instead of the stored solar energy found in coals and oils. He asserts that if it were possible for the hydrogen in seawater to be combined on the earth's surface with helium, oxygen, carbon, nitrogen, silicon, etc., energy would be released in enormous quantities with no violation of any established thermodynamic law. He sketched a future in which science will "almost indefinitely increase the satisfaction of human wants"; saying, "science creates more jobs than it destroys".

Two-Way Radio Phone Demonstrated by Fire Boat



Possibility of maintaining constant communication with shore headquarters two miles distant was demonstrated recently through the use of a two-way radio apparatus installed on the John Purroy Mitchell flagship of New York City's fire fighting fleet. This is one of the first proofs of effective use of radio communication in connection with the fighting of fires and it is expected that it may result in a saving of thousands of dollars annually. Beside doing away with the necessity of responding to false alarms the two-way system permits centralized direction of marine fire forces and greatly improves coordination with land forces.

In the apparatus used for test demonstration, transmission and reception were carried on alternately by means of a small push button on the telephone transmitter. This push-button controls relays which connect either the transmitter or the receiver with the antenna subject to the will of the operator. The Federal Radio Commission already has authorized reciprocal radio stations for this new utilization of radio facilities; the land station in New York will be designated as WCF and the station aboard the New York fire boat will be WRBE.

◆ ◆ ◆

"Cal.-Tech." to Have Astro-Physics Laboratory

A laboratory devoted to research on astronomical and allied subjects is to be built by the California Institute of Technology, Pasadena, as a part of its new 200-in. telescope observatory, to be located in the adjacent mountains. Equipment for the new astro-physics laboratory was described by Emmett M. Irwin, late of the General Electric Company, in a recent address before a Student Branch Meeting in Pasadena. Mr. Irwin now is engaged in research work at the Institute in Pasadena and is contributing much to the general design for the new laboratory and its equipment.

Two features are of particular interest to the electrical engineer; one, a coelostat tower 75 ft. high, to be used in obtaining spectrographs of the sun. The dome of this tower, holding the collecting mirrors, must of necessity rotate with the sun; it will have an independent electrical system of limited power, but maintained at an accurately constant frequency by the oscillation of a piezo-crystal suitably amplified. For precision, this idea supplants the ordinary clockwork method, which because of reverse power fed back from manually-operated mechanisms, is subject to inaccuracies.

The second unique piece of apparatus which Mr. Irwin's plans include is a 200-kw. solenoid to be used in the investigation of solar spectra under the influence of intense magnetic fields, it being supposed that sunlight reaches us at times through intervening magnetic fields in space which break up the spectrum lines into unusual components. As proposed, the coil used will be of 17-in. diameter and five or six feet high. To keep its dimensions within reason, it must be essentially a high-current instrument; leads to the solenoid will be of ¼-x 6-in. copper bars carried through a special tunnel outside the building about 200 ft., from the generator room to the tower. In a laboratory of this nature space for generator layout is limited and great care must of necessity be exercised, problems of interference being very fully debated. Synchronization of units distributed over the building with the main system will be accomplished by Selsyn equipment.

◆

Can Power Come from Tropic Seas?

Power stored in tropic seas is capable of operating electric generating plants of as much as 25,000-kw. capacity, according to assertion made by Professor Georges Claude, famous French scientist, in a lecture before a recent meeting of the American Society of Mechanical Engineers. Reported in the November 1, 1930, issue of *Science News Letter* is an interesting account of Professor Claude's proposal to build a power plant to utilize the hydroelectric possibilities available through the temperature differences between the surface and the deeper water of southern seas. It is asserted that so far as convertible energy is concerned a given installation could be compared with a 300-ft. waterfall.

According to Professor Claude's proposal such a plant could be located near Santiago de Cuba, and could be of sufficient capacity to meet the normal requirements of several thousands of people. Three million dollars is said to be the approximate cost of developing such a plant. This figure, although somewhat greater in proportion than that of the modern steam-electric plant, is said to compare favorably with other hydroelectric installations, all points considered.

In this process of conversion of ocean waters into usable power it is contemplated that the warm surface water would first be vaporized into steam at a very low temperature; the tepid water not being heated but merely subjected to vacuum. Steam so obtained would be passed through a turbine and thence to a condenser cooled by water drawn from a relatively great depth. Thus the cycle contemplated is similar to that of a normal steam-electric generating plant.

Fritz Gold Medal Awarded Admiral Taylor

Wednesday evening Dec. 3, 1930, at the annual dinner of the American Society of Mechanical Engineers, the John Fritz gold medal was awarded Admiral David Watson Taylor, chief constructor of the United States Navy during the World War.

During his whole active career, lasting from 1881 to Jan. 15, 1923, when he was retired from service at his own request, Admiral Taylor's record has been one of unusual achievement and value to both governmental and professional causes, both nationally and internationally.

◆

Biggest Radio Tube

By the grouping together of several of these huge 200,000-watt radio tubes, former Federal Radio Commissioner O. H. Caldwell (standing) now editor of *Electronics* predicts that the million-watt broadcasting station will become a reality. This giant tube has its grid as well as its plate watercooled, the operation requiring approximately 1,250 gallons of cooling water hourly.

In the hope of overcoming static and thus affording better service for millions of people, especially those located in rural districts, Mr. Caldwell, as Radio Commissioner, urged the use of high powered broadcasting stations, and toward this end the above pictured tube seems to be an important step of accomplishment.

A. S. A. Chooses Dr. Gherardi President

The election of Bancroft Gherardi to the presidency of the American Standards Association was announced at the annual meeting of the association Dec. 11, 1930. He will now assume direction of national and international standardization activities for the organization, a task involving more than 2,000 representatives of some 500 national trade, technical, and governmental bodies. Mr. Serrill's work (Mr. Gherardi's predecessor) included the completion of 46 new national standard, in mechanical, electrical, civil, chemicals mining, and woodworking fields during the past year, with a number of safety codes which are now being used by regulatory bodies, by insurance groups, and by industry in behalf of uniform methods for safeguarding the lives and health of workers.

Others taking office in the association under the coming year's elections are, Cloyd M. Chapman, engineering specialist of New York City, re-elected vice-president and chairman of the A. S. A. Standards Council, and John C. Parker, serving as vice-chairman.

◆

Dr. Thomson A. S. M. E. Honorary Member

Doctor Elihu Thomson, past-president and Honorary Member of the Institute and director and founder of the Thomson Laboratory of the General Electric Company at Lynn, Mass., was awarded honorary membership in the American Society of Mechanical Engineers on Dec. 2, 1930, during that society's annual meeting. The presentation was made by Dr. Ambrose Swasey of Cleveland, a past-president of the A. S. M. E.

The importance of Dr. Thomson's scientific and engineering achievements already has received recognition by representative societies of many countries in the form of medals, fellowships and official position. His conspicuous work in behalf of Institute activities is too well known to require further publicity here.

◆

A Tube the Equivalent $5 Billion of Radium

"Wonders of a new X-Ray machine—a 650,000-volt tube" was the subject of Dr. R. A. Millikan's talk before the Radiological Society of North America at its late meeting as reported in the daily press. The tube's potentialities in the fields of medicine, physics and engineering, the noted scientist said, are undeterminable at present.

Its rays approximate the gamma rays of radium, and what may lie ahead in its application for the penetration of metals and of non-homogeneous masses and the molecular structure of human tissues remains for the future to reveal.

New Photoflash Lamp Makes Photography Safe

It is claimed that the dangers from flashlight powders used in photographic work have been conquered to no inconsiderable degree in the production of what will be known as "photoflash" lamp. It is a Westinghouse discovery whereby an ordinary incandescent lamp is reported to be converted into one which will produce a four-million-candlepower flash free of the danger of fire to any inflammable surroundings to which its service may be destined.

There is no smoke, no flame; a glass confines the chemical reaction and all residue. Being similar to the 100-watt household lamp, the photoflash lamp is claimed to operate on any ordinary electric light socket or even from the ordinary handflashlight battery when equipped with the household lamp socket.

Standards

Standardization Projects Reviewed

For those interested in the status of the various electrical standardization projects which are being carried on under American Standards Association procedure, there appears in the November issue of the *A. S. A. Bulletin* a detailed statement covering 35 undertakings. The Institute is serving as sponsor or joint sponsor in 23 of these and is represented in many of the others. Copies of the bulletin may be obtained by addressing A. S. A. headquarters, 29 West 39th Street, New York, N. Y.

A. S. T. M. Standards

The 1930 edition of the triennial book of A. S. T. M. standards has just been issued. It contains 430 standards adopted by the Society and is issued in two parts:—Part I—Metals—standards relating to steel, wrought iron, pig and cast iron, ferro alloys, non-ferrous metals, miscellaneous. Part II—Non-Metals—standards relating to cement, lime, gypsum, concrete and aggregates; brick, refractories and tile; preservative coatings; petroleum products and lubricants; road materials; waterproofing and roofing materials; rubber products and insulating materials; textile materials; coal, coke, timber and miscellaneous. The two volumes may be obtained at the following prices: Part I, cloth $7.50; half leather $9.00. Part II, same prices. Both parts at $14.00 and $17.00 according to binding. Address American Society of Testing Materials, 1315 Spruce St., Philadelphia, Pa.

Electrical Definitions

The Sectional Committee on Electrical Definitions of which the Institute is sole sponsor and that is engaged in what is virtually the compilation of a dictionary of American standard definitions in the electrical field, is now reaching a point in its work where results are showing. Certain of the 15 sub-groups to which the work has been allocated are furnishing reports in a status suitable for setting in type for final distribution. The work is slow because of the care with which it must be carried on and the necessity of obtaining approval of all interested bodies.

In their preliminary reports the various chairmen are confining themselves to those definitions on which there is no question. Others will follow later as difficulties are ironed out and inconsistencies eliminated. Those groups which are advanced farthest at present are, illumination, transportation, control and transmission. When the work is completed the publication containing the complete report will be of great value to the electrical industry.

Personal

F. D. Newbury, former manager of the power engineering department of Westinghouse at East Pittsburgh, has been appointed general manager of machinery engineering; R. A. McCarty succeeds him in the power engineering department managership.

T. A. Fawell has made new business connections with the Marwood Company of San Francisco, which operates in six Pacific Coast cities under its various local organizations in its activities of repair and construction of motors and shop equipment.

Claxton A. Allen, formerly manager of the southwestern district of Westinghouse Electric & Manufacturing Company, was elected a commercial vice-president at a recent meeting of the company's board of directors. Mr. Allen's duties of coordination will extend to the domestic appliance division and others serving the household market, including refrigeration, radio, etc.

Everitt W. Wilson, formerly vice-president of R. W. Hebard Co., Inc., of New York, and later foreign representative for the J. G. White Engineering Corporation of New York, now is associated with Winston Brothers Company of Minneapolis, Minn., as representative for the negotiation of contracts outside of the United States.

Obituary

William B. Clarkson, of the industrial control engineering department of the General Electric Company, Schenectady, and since 1919 an Associate of the Institute, died Oct. 23, 1930, at the Long Island City College Hospital, Brooklyn, N. Y., after an illness of several weeks.

He was a native of Brooklyn (December, 1892) and held two professional degrees, A. B. from Williams College in 1913 and M. E. E. from Harvard Graduate School of Engineering in 1915. His professional work with the General Electric Company originated in 1915 when he became test man in the Schenectady works; in 1917 he advanced to the position of engineer of the industrial control department of the same Company. In August of that year he received his commission as a second lieutenant of engineers, assigned to the 303d Engineers as supply officer for the 1st Battalion in British Area. He was discharged from military service in 1919 as a first lieutenant and returned to the industrial control department of the General Electric Company.

Edmund D. McCarthy, president of McCarthy Brothers and Ford of Buffalo, N. Y., died suddenly Dec. 13, 1930, of heart failure.

He had been in the electrical business for more than 35 years and was prominent in the field of electrical contractors and jobbers in the State of New York. His efforts had been principally for the betterment of the electrical industry, serving as general chairman of the Electrical League of the Niagara Frontier, past-president of the Buffalo Electrical Contractors Association, and as a director of numerous companies including the Marine Trust Company, the Iroquois Share Company, and the Buffalo Chamber of Commerce. For many years he was in the New York National Guard, in which he rose to the rank of major. He joined the Institute as Associate in 1896 and also was a member of the Engineering Society of Buffalo and numerous local recreative groups including Buffalo Canoe, Buffalo Athletic, Cherry Hill, and Buffalo Country Club.

Andrew M. Hunt, consulting engineer and past member of the Institute died at Berkeley, California, Dec. 8, 1930, in his 72d year. He was a graduate of the Annapolis Naval Academy and had become prominent in both mechanical and electrical engineering fields. Upon extending his resignation from the navy, Mr. Hunt opened his own offices as consulting engineer in San Francisco, but in 1915 he came to New York to head the firm of Peyton-Hunt Company, Inc. His appointment to the Naval Consulting Board took place in 1917. Mr. Hunt was a member of the American Society of Mechanical Engineers, the American Institute of Consulting Engineers, the American Chemical Society, and numerous other technical bodies.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring prompt delivery of Institute mail, the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work:

Bates, Putnam A., 117 W. 72nd St., New York, N. Y.
Cromwell, R. C., 1814 Harris Trust Bldg., Chicago, Ill.
Dawson, Leonard L., 98 Looker Ave., Springfield, N. J.
Fielding, Geo. T., General Cable Corp., Graybar Bldg., New York, N. Y.
Hursh, G. E., 345 Lenox Road, Brooklyn, N. Y.
Lieb, Adolph W., N. Y. Edison Co., 393 Seventh Ave., New York, N. Y.

Engineering Index

Engineering Index Service
29 West 39th Street, New York, N. Y.

Selected references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals.

All articles indexed are on file in the Engineering Societies Library, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

ARCS

Carbon. A Geometrical Analysis of Open Carbon Arc Phenomena, W. Cramp and A. P. Jarvis. *Instn. Elec. Engrs.—Jl.* (*Lond.*), vol. 68, no. 406, Oct. 1930, pp. 1301-1312, 11 figs. Behavior of carbon arc with resistance in parallel is developed geometrically and proved experimentally; conditions governing musical arc analysis show that musical arc, in which current oscillates about point on volt-ampere characteristic, is possible but that it is unstable; tendency for arc oscillations to grow until extinction ensues is traced; necessity for introduction of thermal term in equations.

BATTERIES

Storage. Characteristics of Secondary Batteries Under Reduced Atmospheric Pressure, S. Makio. *Electrotech. Soc. Waseda—Jl.* (*Tokyo*), vol. 11, no. 10, Oct. 1930, pp. 359-364, 5 figs. Result of investigation, contrary to Dolezaleck's conclusion, shows that capacity of accumulator is increased under reduced pressure and that this increased capacity is maintained for a while, even after accumulator is brought out in ordinary atmospheric pressure, and then, gradually returns to its normal value in atmospheric pressure with repeated charges and discharges. (In English.)

BOULDER DAM PROJECT

The Boulder Canyon Project. *Eng. and Contracting*, vol. 69, no. 11, Nov. 1930, p. 398. Construction features of $165,000,000 dam and reservoir, irrigation canal, and power development by U. S. Bureau of Reclamation; Hoover dam will be about 727 ft. above foundation rock; power plant capacity will be 1,000,000 or 1,200,000 hp.; All-American canal will be 75 mi. long, and Coachella branch will be 115 mi. long; new town will be located about 6 mi. due west of dam site.

CABLES

High-Tension—Joints. Super-Tension Cable Jointing, J. Riedl and R. S. Dawson. *Elec. Engr. of Australia and New Zealand* (*Melbourne*), vol. 7, no. 6, Sept. 15, 1930, pp. 205-208, 7 figs. Method adopted by Australian Siemens Concern in jointing 33-kv. cable for Municipal Council of Sydney.

Underground. 1920-1930 Report Underground Systems Committee. *Nat. Elec. Light Assn.—Reports of Committees*, for mtg. Sept. 25-27, 1930, 57 pp., 20 figs. Résumé of outstanding accomplishments of Committee for administrative year together with recommendations for future study; complete papers on Underground or Cable Distribution Systems in Outlying Territory, Requirements of Good Cable Training, Preparation of Specifications and Standards, Fault Localization in Distribution Cables, Twenty-Ampere Series Street Lighting Circuits, The Use of Eight-Pole Potheads for Multiplying 100-Ampere Primary-Feeder Cables, etc.

CAPACITORS

The Application and Performance of Series Capacitors, M. I. Alimansky. *Gen. Elec. Rev.*, vol. 33, no. 11, Nov. 1930, pp. 616-625, 17 figs. Function of capacitors; comparison with other regulative equipment; applications for line regulation, for division of load in loop circuits, protection of equipment, analysis of capacitor installation; article is followed by report of sub-committee on series capacitors for voltage regulation in which table is shown of line drop in per cent of receiver voltage when all reactance is neutralized by series of capacitors; also chart useful in transmission-line design.

CIRCUIT BREAKERS

Oil. New Departure in Oil Switch Fuse Design. *Elec. Times* (*Lond.*), vol. 78, no. 2036, Oct. 30, 1930, pp. 751-752, 3 figs. Rotary switch action applied to oil switches secures important advantages and safety of operators.

COMMUTATORS

Electric. Phenomena Connected With the Collection of Current From Commutators and Slip-Rings, H. G. Taylor. *Instn. Elec. Engrs.—Jl.* (*Lond.*), vol. 68, no. 406, Oct. 1930, pp. 1356-1363, 16 figs. Experimental investigation of copper picking, followed by critical survey of existing data, leading to explanation to account for this deposition of metal, and investigation into mechanism of passage of current from slip ring or commutator to brush; variation of contact voltage drop with speed, brush pressure and current is shown. Bibliography.

CONDENSERS

Induction Motor. The Use of Condensers for Operating Single-Phase Induction Motors. *Elec. News* (*Toronto*), vol. 39, no. 12, Nov. 1, 1930, pp. 50-51, 5 figs. Use of condensers for generating artificial rotary field; starting of electric motors for domestic use; systems and connections are shown.

Static. Static Condensers as Phase Compensators (Statische Kondensatoren als Phasenkompensatoren), A. Imhof. *Schweiz. Electrotechnischer Verein* (*Association Suisse des Electriciens*)*—Bul.* (*Zurich*), vol. 21, no. 20, Oct. 22, 1930, pp. 653-666, 12 figs. Construction of condensers for reactive power compensation, economic limits; numerical example in which is shown how power-factor improvement can lead to savings in power cost; economic advantages of static condensers over rotating equipment; space requirements; accessories.

CORONA

Loss Measurements. The Measurement of Corona Losses, F. M. Denton. *Gen. Elec. Rev.*, vol. 33, no. 11, Nov. 1930, p. 615, 2 figs. Current measurements on line were taken with one line grounded; combination with stroboscopic measurements; in addition to measurements such as usually are made on low voltage side of transformer supplying power to line.

EDUCATION

Engineering. Present Trends in Engineering Education, H. Tucker. *Eng. News-Rec.*, vol. 105, no. 21, Nov. 20, 1930, pp. 806-807. Colleges and universities foster multiplication of types of engineers by providing many special vocational courses; vocational aim in engineering education; branches of engineering included in curricula of 71 schools; lack of uniformity; five main divisions of engineering; modern languages in curricula; broader engineering classifications needed.

ELECTRIFICATION

Coal Mines. Modernizing a Large Western Coal Mine with Electricity, R. S. Trowsdale. *Elec. News* (*Toronto*), vol. 39, no. 21, Nov. 1, 1930, pp. 47-49, 5 figs. Crow's Nest Pass Coal Co. in British Columbia, was operated entirely by steam power; in 1928 it was decided to purchase number of large air compressors, and question of economical purchase of power came up for consideration; power supply is from East Kootenay Power Co.; suitable substation provided by power company adjoining compressor station; primary current at 66,000 volts is transformed to 2300 volts for 600 and 400 hp. 3-phase 2300-volt motors.

Copper Mines. Electrification of the Utah Copper Mine, R. Corfield. *Gen. Elec. Rev.*, vol. 33, no. 11, Nov. 1930, pp. 600-607, 14 figs. Reasons why electric shovels and locomotives are used in one of largest mining undertakings in world; comparative shovel costs and comparative shovel characteristics; power input graphs for d-c. and a-c. shovels; electric locomotives; overhead line construction; locomotive data; control room; power transmission; specifications of forms of electric locomotives and shovels.

ELECTRIC DRIVE

Iron and Steel Plants. A Comparison of Alternating-Current and Direct-Current Motors for Auxiliary Drives, G. Fox. *Iron and Steel Engr.*, vol. 7, no. 10, Oct. 1930, pp. 505-511, 7 figs. In planning for expansion of steel industry of U.S.S.R., German consultants, reflecting prevailing German practice recommended use of a-c. auxiliary motors while Americans recommended 230 volt d-c. motors for services of intermittent character where mill-type motors are applicable; as this is question wherein experience and judgment are of greater importance than theoretical considerations, writer addressed questionnaire to 20 members of A.I.S.E.E. soliciting opinions and comment; analysis of questionnaire.

Paper Machinery. Modern Standards in Sectional Paper Machine Drive, R. R. Stoltz. *Paper Trade Jl.*, vol. 91, no. 15, Oct. 9, 1930, pp. 49-51, 7 figs. Automatic speed regulation by field control, moderate-speed geared motor, automatic starting and speed control equipment concentrated in single control board, generator system of starting, inching and slow speed operation, carbon pile voltage regulators individual drive of cylinder moulds and presses on wet end of board machines, carbon pile sectional speed regulator.

Strip Mills. Synchronous Motors for Main-Roll Drive, H. W. Harper. *Elec. Jl.*, vol. 27, no. 11, Nov. 1930, pp. 657-659, 4 figs. With increasing amount of attention now given to power-factor conditions, and notable improvements made in design of synchronous motors, this type of drive merits serious consideration for almost any large or reasonably large constant-speed application.

FURNACES.

Electric Furnaces, V. O. Cutts. *Elec. Rev.* (*Lond.*), vol. 107, no. 2760, Oct. 17, 1930, pp. 617-619, 5 figs. Application to industrial heating, with special reference to resistance type; notes on growing application; continuous-type furnaces; precision in heat treatment; bright annealing; vitrous enameling; high-temperature furnaces; economic considerations; ideal electrical load.

Melting Cast Iron. Using Off-Peak Power for Melting Gray Iron, W. R. Jennings. *Metals and Alloys*, vol. 1, no. 17, Nov. 1930, pp. 814-815, 1 fig. Experiences of Baker-Perkins Co. of Saginaw, in operating rocking type electric furnace on cold stock melting of gray iron; charts illustrate how demand was reduced from 960 kv-a. to 640 kv-a., difference of 320 kva. which represents saving in demand charge of $5500.00 per yr.; using 590 kw-hr. per heat, cost of electrical energy per pound is 0.00295 cent.

Heat Treating. High-Speed Steel Treated in a Special Electric Furnace, E. N. Brookings. *Iron Age*, vol. 126, no. 19, Nov. 6, 1930, pp. 1295-1298, and 1360, 2 figs. Details of construction and operation of electric hardening furnace at plant of Jones and Lamson Machine Co., Springfield, Vt. for treating threading chasers for automatic dies, taps, lathe tools, and miscellaneous parts.

FUSES.

Rupturing Characteristics of High-Tension Fuses. *Elec. World*, vol. 96, no. 19, Nov. 8, 1930, pp. 870-871, 4 figs. Tests conducted for several years by Alabama Power System at short-circuit laboratory constructed for purpose at Bessemer substation; data indicate satisfactory operation at currents up to peak value of over 8500 amperes at 44 kv. and nearly 2000 amperes at 110 kv.

Re-Fusing Switches. Pole-Top Re-Fusing Made Easier, C. L. Lawrie. *Elec. West*, vol. 65, no. 5, Nov. 1, 1930, p. 233, 2 figs. To provide quicker and safer method of re-fusing poletop line switches on its 12-kv. distribution lines without resorting to use of hot-line tools and without killing line, new switching arrangement has been developed by San Diego Consolidated Gas & Electric Co.; system is detailed.

HEATERS

Water. Economic Advantages of Off-Peak Water Heating, L. L. Eden. *Elec. World*, vol. 96, no. 19, Nov. 8, 1930, pp. 863-869, 6 figs. Typical winter and summer loads showing availability of off-peak power; favorable characteristics of off-peak load; comparative cost of on and off-peak water heating; typical load curves of city and suburban a-c. substation for December and June; performance of water heaters at various hours and rates of water usage; comparative cost of fuels for water heating.

HEATING

Domestic. Off-Peak System of Electric Heating for Buildings, E. Harrington. *Heat., Piping and Air Conditioning*, vol. 2, no. 11, Nov. 1930, pp. 963-967, 6 figs. Operating cost of electric heating depends upon number of variables, among which are power rate and characteristics of building to be heated; table illustrates energy used for electrically heating 18 houses, Fort Wayne, Ind.; list of advantages of electric heating; domestic water heating.

HYDRAULIC MACHINERY

Cavitation. Experimental and Theoretical Investigations of Cavitation in Water [Experimentelle und theoretische Untersuchungen ueber Hohlraumbildung (Kavitation) in Wasser], J. Ackeret. *V. D. I. Zeit.* (*Berlin*), vol. 74, no. 9, Mar. 1, 1930, p. 264. Investigation of simple types of flow, such as those round blades, through channels, and past spheres, has been done at Goettingen; it was found that many apparently widely different types of cavitation are of quite common characteristics; investigations show that at core of bubbles shock pressure is sufficient to cause observed breakdown of material.

HYDROELECTRIC POWER PLANTS

Report of Hydraulic Power Committee (Eng. Sec.) presented at 23rd annual mtg. of Pa. Elec. Assn. (Eastern Geographic Div. N.E.L.A.), Bedford Springs, Pa., numerous figs. and tables. Minutes of meetings; manufacturers' statements as to volume and equipment of hydro-electric installations; during past 12 months orders were placed for Smith turbines developing more than 591,000 h.p., including 81,900 h.p. in propeller type units; Flow Measurement and Forecasting at Holtwood, H. W. Lowy. Output Standards for Hydraulic Units, C. W. Watchorn; Keeping Daily Record of Capacity of Hydro Units, R. D. Shaub; Distribution of Runoff and Rainfall in Susquehanna Valley, C. F. Merriam and E. S. Loane; Seiches in Conowingo Pond, R. Taylor and R. E. Turner; Progress in Remodeling York Haven Hydro-Electric Station, A. W. Reid; list of dam failures.

Ice Control. Ice-Trouble Remedies in Hydro-Electric Plants, C. R. Reid. *Power*, vol. 72, no. 19, Nov. 4, 1930, pp. 728-730, 7 figs. How to keep sluice gates, flashboards, rack bars, headgates, penstocks, surge tanks and waterwheels in operating condition in cold climates; use of steam, hot water and electric heating, compressed air, and electric lights are included in suggested methods.

INSULATORS

Testing. Field Testing of Insulators on Overhead Lines, D. Harvey. *Distribution of Electricity* (*Lond.*), vol. 17, no. 2, Oct. 1929, pp. 223-225, 3 figs. Mechanical faults are particularly noticeable among "cap and pin" type of suspension insulator; "Hewlett" type of insulator, in which hardware is interlocked so that porcelain is in compression, appears to give slightly better service than "cap and pin" types; string type insulators for excellent results; authors experience with string type insulators in 88 kv. line. Extracts from lecture recently delivered to Inst. of Engrs. in Tasmania. (To be concluded.)

INTERCONNECTION

Industrial Power Plants. Engineering Aspects of Interchange of Power With the Industrial Plants, B. F. Wood. *Am. Soc. Mech. Engrs.—Advance Paper*, no. 57, for mtg. Dec. 1-5, 1930, 5 pp. Establishment of means and facilities for utilizing massed resources to serve power requirements of individual industries; economical operations can be effected and overhead costs greatly reduced in great many cases where public utility or other steam-generating or hydro power plants find it possible to hook up with large industrial operations; advent of high steam pressures has largely increased these possibilities.

LAMPS

Gas-Filled. Electric Lighting by Gaseous Discharge Tubes, C. C. Paterson. *Engineering (Lond.)*, vol. 130, no. 3381, Oct. 31, 1930, p. 560. Abstract of portion of presidential address before Institution of Electrical Engineers, dealing with gaseous discharge tubes; although so much work has been done on hot cathode tube, many interesting developments of original cold cathode tubes are taking place; under certain conditions, which are only just beginning to be understood discharge instead of filling whole tube, as is normally the case is concentrated into narrow cord only one-fifth of diameter of tube.

Glow. Duration of Emission Phenomena in Glow Lamps (Ueber die Zeit-dauer der Emissionserscheinungen bei Glimmlampen), H. Peters. *Fernsehen (Berlin)*, vol. 1, no. 7, July 1930, pp. 306-310, 2 figs. Quality of picture in television greatly depends on design of glow lamp; investigation of inertia phenomena in this device allows for making conclusions which are of importance in instruction.

Street—Reactors. Investigation of Choke Coils for Parallel Connection to Incandescent Lamps in series for Keeping up of Operation in Case of Burn-out of Lamps (Untersuchung ueber Drosselspulen zur Parellelschaltung mit Gluehlampen, die in Serie geschaltet sind, zur Aufrechthaltung des Betriebes bei Durchbrennen einer oder mehrerer Lampen), I. Ehrenstein. *Elektrotechnik und Maschinenbau (Vienna)*, vol. 48, no. 40, Oct. 5, 1930, pp. 913-915, 5 figs. Performance, characteristics and design data for reactive coils hooked in parallel to lamps in series street lighting for emergency in case of lamp burn-out.

LIGHTING

Industrial. Light and Its Relation to Output, H.C. Wheat. *Machy. (Lond.)*, vol. 37, no. 942, Oct. 30, 1930, p. 135. Relative advantages of various lighting arrangements; good artificial lighting promotes safety, increases production, reduces errors and improves morale of employees; proper use of various types of reflectors; data on light intensities in machine shop. Abstract of paper read before Rugby Eng. Soc.

LIGHTNING ARRESTERS

Lightning Arrester Practise in Southern California, E. R. Stauffacher. *Elec. West*, vol. 65, no. 5, Nov. 1930, pp. 230-231, 5 figs. Instead of following older practise of installing one set of lightning arresters upon each of lines entering and leaving substation, Southern California Edison Co., Ltd., is now following simplified practise of installing lightning arresters only on transformer banks; details of system are given.

MEASUREMENT

Stresses. Use of Telemeters for Measurement of Stresses in Structures (Die Verwendung von Telemetern zu Spannungsmessungen au Bauwerken), F. Treiber. *Bauingenieur (Berlin)*, vol. 11, no. 37, Sept. 12, 1930, pp. 633-636, 14 figs. Description of instrument developed by U. S. Bureau of Standards and report on German tests of this instrument by Probst, at Karlsruhe Institute of Technology.

Electric. Metering Combined Power and Lighting Loads, H. W. King. *Elec. World*, vol. 96, no. 17, Oct. 25, 1930, pp. 774-776, 11 figs. Condition, varying from large power load with small lighting load to large lighting load with small power load, with or without demand with diversity factor included, defeat adoption of one uniform metering scheme for all cases; it is illustrated how some of these conditions may be met and to point out advantages or disadvantages of various combinations which may be used.

Reactive Power. Reactive Kv-a. Metering, E. C. Goodale. *Elec. West*, vol. 65, no. 5, Nov. 1, 1930, p. 232, 2 figs. Cross-phase connections provide required phase relations for reactive kv-a. metering on two-phase circuit. (Continuation of serial.)

MOTORS

Torque. Torque Characteristics of Electric Motors, W. T. Burdick. *Power Transmission*, vol. 37, no. 3, Sept. 1930, pp. 15-17. Common types of direct and alternating-current motors; starting torque, full-load running torque, and maximum torque; table of characteristics and typical applications of motors.

Variable Speed. Multispeed Motors for a Multitude of Uses, R. H. Rogers. *Power Plant Eng.*, vol. 34, no. 22, Nov. 15, 1930, pp. 1289-1292, 5 figs. Two, three and four-speed, speeds available, speed control, and examples of applications.

NETWORKS

Design. Municipalities Gain from Network Distribution, A. Hussey. *Elec. World*, vol. 96, no. 17, Oct. 25, 1930, pp. 770-772, 8 figs. Under present system it is possible to transmit as much power as under old d-c. system in duct space reduced in ratio of 51 to 1; this has been made possible by development of cable capable of operating at 27,000 volts with high degree of dependability, and of automatic protective devices to clear cable or other device in event of failures; as direct result of decreased duct space and increased capacities, number of line manholes and dimensions of these manholes have been reduced.

OSCILLOGRAPHS

Cathode Ray. Cathode-Ray Oscillograph as Precision Measuring Equipment (Der Kathodenoszillograph als Praezisionsmessgeraet), H. Viehmann. *Archiv fuer Elektrotechnik (Berlin)*, vol. 24, no. 3. Sept. 27, 1930, pp. 349-352, 6 figs. Determination of overvoltage and spark-delay time in puncture testing of air required exact values of first mentioned; it is investigated whether cathode-ray oscillograph is suitable equipment for this purpose.

PHOTOELECTRIC CELLS

Photo-electric Cells, T. T. Baker. *Elec. Rev. (Lond.)*, vol. 107, no. 2762, Oct. 31, 1930, pp. 722-723, 5 figs. Some industrial applications; effect of voltage on output for vacuum cell and gasfilled cell; effect of gas-pressure on output; photoelectric cell circuits. (To be concluded).

POWER SUPPLY

Rural. The National Rural Electric Project and the Agricultural Problem, G. W. Kable. *Baltimore Engr.*, vol. 5 no. 7, Oct. 1930, pp. 4-8 and 24, 7 figs. Aim of project is to improve living conditions and income on American farms, to lessen fatigue and to increase leisure time of farm homemakers, and to ascertain truth concerning economic use of electricity on farm; work consists of practical demonstration of possible uses of electricity on farms, together with investigation and research in application of electricity to agriculture.

Present Status of Research in Rural Electrification, G. W. Kable. *Nat. Elec. Light Assn.—Bul.*, vol. 17, no. 11, Nov. 1930, pp. 693-695, 1 fig. Electrification of agriculture is not problem in motorizing of industry; farming bristles with problems in chemistry, physics, biology, bacteriology, economics and sociology, all of which may be influenced to degree through application of electricity.

PUBLIC UTILITIES

Legislation. Some Influences on Public Utility Legislation, A. F. Tegen. *Nat. Elec. Light Assn.—Bul.*, vol. 17, no. 11, Nov. 1930, pp. 682-685, 8 figs. Net earnings of electric utilities are not excessive when considered in relation to other businesses; if this industry is to maintain its position with respect to its ability to obtain money for improvements, conditions under which it is operating should not be disturbed; analysis of municipal and private utility operation in Wisconsin reveal that whereas municipal utilities started with more revenue per kw-hr. they ended with less.

RADIO

Screen Grid Amplifiers. Application of Screen Grid Tubes to Audio Frequency Amplifiers, J. J. Glauber. *Radio Eng.*, vol. 10, no. 2, Feb. 1930, pp. 29-32 and (discussion) 32-33, 10 figs. Construction of proper circuits suitable to characteristics of typical screen-grid tube. Paper presented before Radio Club of America.

Communication Aerial. Radio for Aircraft. *West. Flying*, vol. 8, no. 5, Nov. 1930, pp. 40-41, 1 fig. Review of recent progress with particular regard to new Department of Commerce regulations governing aircraft radio equipment; effective Dec. 31; advantages of two-way radio phone communication.

Ultra Short Wave. Practical Experiments in Ultra-Short Wave Communication, C. C. Whitehead. *Experimental Wireless (Lond.)*, vol. 7, no. 86, Nov. 1930, pp. 612-620, 11 figs. Range tests and propagation; screening of envelopes of valves, asymmetry of circuit; estimation of transmitter efficiency, effect of time of transit of electrons constituting space-current, constructional details of transmitter and constructional details of receiver, are given in appendix. Bibliography. (Concluded.)

Developments in Ultra-High Frequency Generation, C. W. Loeber. *Electronics*, vol. 1, no. 8, Nov. 1930, p. 376, 2 figs. Barkhausen-Kurz effect was produced with triode with strong positive voltage on grid; voltages determined frequency; wavelength was measured by moving crystal detector along Lecher wires; Gill and Morrell's oscillating circuit in which frequency could be varied by telescoping tubes.

RAILROADS

Electrification—United States. N.E.L.A. Electrification Report. *Ry. Age*, vol. 89, no. 19, Nov. 8, 1930, pp. 974-979, 6 figs. Study of installations on western railroads has developed much useful information concerning operation and maintenance.

Operation. Scheduled Speed Increased by Electrification. *Elec. Ry. Jl.*, vol. 74, no. 12, Nov. 1930, pp. 683-684, 2 figs. Rapid acceleration and braking rates of new electric trains have enabled Lackawanna Railroad to reduce running time by approximately 25 per cent between Hoboken and stations in suburban zone; free running speed also higher than that of steam trains formerly operated.

Substations. The Design and Operation of the Windsor, Essex and Lake Shore Railway Automatic Substations, H. V. Armstrong. *Elec. News (Toronto)*, vol. 39, no. 21, Nov. 1, 1930, pp. 31-34, 5 figs. Diagram of automatic switching equipment for synchronous converters in railway service; sequence of operation; 26.4 kv. switching equipment of notes on operation of 36 mi. line connecting Windsor to Leamington and running through Maidstone, Essex, Cottam, Ruthven and Kingsville, serving county of Essex.

Terminal Electrification. Overhead System of Cleveland Terminal Electrification, L. W. Birch. *Elec. Traction*, vol. 26, no. 10, Oct. 1930, pp. 535-537, 3 figs. Review of electrified terminal stations; 3000 volts d-c. decided upon; insulation details of overhead.

REACTORS

Design. Current-Limiting Reactors, A. H. v. Altmann. *AEG Progress (Berlin)*, vol. 6, no. 11, Nov. 1930, pp. 341-345, 7 figs. Calculation and effects of short-circuit currents; impedance calculation of short-circuit path; thermal and dynamic effects of short-circuit current; construction and installation of current-limiting reactors.

RECTIFIERS

High-Tension. Generation of High-Tension Direct Current from Three-Phase A.C. Current (Die Erzeugung von hochgespanntem Gleichstrom aus Drehstrom), W. Deutsch and W. Hoss. *Elektrotechnische Zeit. (Berlin)*, vol. 51, no. 43, Oct. 23, 1930, pp. 1480-1483, 18 figs. Construction, performance and application of novel mechanical high-tension rectifier by which it is possible to obtain d.c. of voltage approximately equal to maximum value of transformer voltage.

RELAYS

Protective. D.-C. Undervoltage Relay Controls A-C. Circuits, W. M. Brainard. *Power*, vol. 72, no. 19, Nov. 4, 1930, pp. 725-727, 5 figs. Inductor-type d-c. time-delay undervoltage release has been developed that is applied through copper-oxide rectifier to protect a-c. equipment against voltage failures; applications diagrams of inductor-type time-delay device.

TELEVISION

History. Historical Development of Television (Die Geschichtliche Entwicklung des Fernsehens), W. Friedel. *Fernsehen (Berlin)*, vol. 1, no. 1, Jan. 1930, pp. 12-17, 5 figs. General notes on development from 1875 to present.

Life Size. Life Size Television on the Screen (Fernsehen in Lebensgroesse auf der Leinwand), A. Neuburger. *Fernsehen (Berlin)*, vol. 1, no. 10, Oct. 1930, pp. 460-463, 3 figs. Successful transmission by Dr. Alexanderson of picture and voice of living persons and actors over distance of some miles on 10 by 11 ft. screen in 2500 persons theater in Schenectady; equipment is illustrated.

TRANSMISSION LINES

Construction. The Stringing and Sagging of Overhead Line Conductors, H. W. Settle. *Elec. Engr. of Australia and New Zealand (Melbourne)*, pp. 209-213, 5 figs. Practical methods for overhead transmission lines and of tensioning them to correct sag, particularly in rough country; several methods of sagging are given, some involving use of theodolite; wave method, in which sag is determined from speed of travel along wire of mechanically produced wave.

Gounding. Further consideration is Needed on Grounds and Ground Testing, W. B. Buchanan. *Elec. Canada (Toronto)*, vol. 2, no. 9, Sept. 1930, pp. 22-24 and 34, 1 fig. Subject is outlined so that various views presented may appear in proper relation to entire subject and less contradictory to one another than they occasionally have done.

Protection. Summation Transformer Gives Overcurrent Protection, R. E. Cordray. *Elec. World*, vol. 96, no. 19, Nov. 8, 1930, p. 872, 2 figs. To raise ampere setting of overcurrent relays automatically on two parallel lines when one of lines is temporarily out of service for any reason, New England Power Co. adopted novel arrangement by bridging auto-transformer by overcurrent relay and connecting midtap to common connection of cross-connected current transformers.

Theory. Transmission of High-Frequency Oscillating Electric Power (Die Fortleitung hochfrequenter elektrischer Schwingungsenergie), H. O. Roosenstein. *Zeit. fuer Hochfrequenztechnik (Frankfort)*, vol. 36, no. 4, Oct. 1930, pp. 121-123, 17 figs. Data of lines applied in practise; wave resistances, damping, numerical example; theory of damping measurements; observation of safety in measurements, etc.; asymmetry of two wire lines; experiments, removal of line asymmetry.

TRANSMISSION LINES, HIGH TENSION

Design. Transmission Tower Design for Maximum Lightning Protection, Fortescue. *Elec. Jl.*, vol. 27, no. 11, Nov. 1930, pp. 640-644, 8 figs. Calculated results for tower of horizontal construction with transmission lines 76 ft. above surface of earth and ground wires in vertical plane 25 ft. above line wires is given; from curves can be determined necessary length of insulator string to withstand surge potential due to lightning stroke on ground wire or value to which tower-footing surge impedance must be reduced in order to prevent flashover of given length of string.

Protection. Protection from Surges, E. T. Norris. *Elecn. (Lond.)*, vol. 105, no. 2734, Oct. 24, 1930, pp. 496-497, 3 figs. Safeguarding of apparatus against lightning and other surges; discharge arresters giving place to surge absorbers.

Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 27, no. 11, Nov. 1930, pp. 660-668, 37 figs. Notes on apparatus protective relays; equipment is illustrated; characteristic curves are given. (Continuation of serial.)

TRANSFORMERS

Current. Factors in Connecting Secondaries of Current Transformers, J. Auchincloss. *South Power Jl.*, vol. 48, no. 11, Nov. 1930, pp. 51-53, 4 figs. When current transformer secondaries should be connected in series and when in parallel, and effect of each connection on division secondary burden; analysis of problem.

Oil-Immersed Current Transformers, I. H. Sclater. *Gen. Elec. Rev.*, vol. 33, no. 11, Nov. 1930, pp. 658-659, 6 figs. New types of oil immersed current transformers and described under headings; accuracy; connections; bushings tanks; by-pass protectors.

TURBO-GENERATOR

Rotors. Stresses in Retaining and Centering Rings for Turbine-Generator Rotors, R. Patterson and D. H. Harms. *Am. Soc. Mech. Engrs.—Advance Paper*, no. 42, for mtg. Dec. 1-5, 1930. 9 pp., 8 figs. Distribution of stresses throughout system of parts enclosing rotor coil ends of turbine generator; system consists of disk of uniform cross-section cylinder, and part of shaft; summary of significant results.

VACUUM TUBES

Filaments. The Role of Barium in Vacuum Tubes, J. A. Becker. *Electronics*, vol. 1, no. 8, Nov. 1930, pp. 390-391, 2 figs. It is shown how ionic barium grid accounts for many of observed emission characteristics of coated filaments; for all thousands of tubes in use in Bell System total amount of effective barium is not more than twentieth of gram; each barium-coated filament requires only about 2.2 watts for heating as compared to about 35 for clean tungsten filament; multiplying this saving by 250,000 tubes used in Bell System gives indication of tremendous importance of barium to vacuum tubes.

Oscillators. The Effect of Combined A.C. and D.C. Plate Supply on a Short Wave Triode Oscillator, G. S. Field. *Can. Jl. Research (Ottawa)*, vol. 3, no. 4, Oct. 1930, pp. 287-290, 3 figs. By combining a.c. and d.c. on plate of triode oscillator, more stable and much stronger oscillations were obtained than with pure d.c.; increases in radio frequency current up to 2.5 times were noted; experiments with 200-cycle and 60-cycle a-c. showed that higher frequency gave stronger oscillations.

Rectifier. Vacuum-Tube Rectifiers Control Motor Speed, W. R. King.

Power, vol. 72, no. 20, Nov. 11, 1930, pp. 761-763, 6 figs. Operation of thyratron, mercury-arc rectifier with grid control, and its application to control speed of d-c. motors supplied by a-c. circuits; diagram of single-phase full-wave grid-controlled thyratron rectifier.

WATER POWER

United States. Federal Relations to Water-Power Development, F. E. Bonner. *Am. Soc. Mech. Engr.—Advance Paper*, no. 8, for mtg. Dec. 1-5, 1930, 3 pp. Survey of part played by Federal Government; Federal jurisdiction over navigable streams; purpose of Federal Water-Power Act; activities of Federal Power Commission; aggregate capacity of water power plants under license.

WELDING

Arc. Application of Electric Arc Welding to Building and Machine Construction, J. M. Hipple and G. D. Fish. *Eng. and Finance*, vol. 23, nos. 4 and 5, Oct. 1930, pp. 111-112, and Nov., pp. 145 and 158, 8 figs. Abstract of paper presented before Inst. Congress of Steel Construction, Belgium, and previously indexed from Welding Engr., Sept. 1930. (To be continued.)

Arc—Atomic Hydrogen. Welding with Atomic Hydrogen Process, S. Martin, Jr. *Welding*, vol. 1, no. 13, Nov. 1930, pp. 907-909 and 912, 7 figs. Fundamental principles and electric equipment; connection diagram for atomic-hydrogen arc-welding equipment; graph illustrates tungsten electrode consumption, average welding speed, and average welding curve for steel plates.

Buildings, Steel. Welding a 14-Story Building, J. L. Faden. *Elec. World*, vol. 96, no. 18, Nov. 1, 1930, pp. 824-829, 10 figs. Details of electric welding of two Boston Edison Co.'s buildings; nearly mile of electric welds, consuming 6120-kw-hr.; 1054 tons of steel welded; average inches of weld per man per hr. 47.4; operators selected to qualify for this important undertaking; building welds specified in detail; advantages of welding; summary of welding inspection reports; welding data; details of welded steel frames.

Pipe, Ste l. Electrically welded Steel Water Pipe, W. H. Powell. *Can. Engr. (Toronto)*, vol. 59, no. 19, Nov. 1930, pp. 599-604, 5 figs. Description of methods used in making and testing of 50,000 ft. of pipe in British Columbia for Greater Vancouver water district's system; butt-weld and lap-weld tests; fitting pipe sections; cleaning and dipping; manufacturing pipe bends; hand-weld and machine-weld tests; hydrostatic test; pipe diameters varied from 26 to 36 in.

X-RAY APPARATUS

The Development of Modern X-Ray Generating Apparatus, W. D. Coolidge. *Gen. Elec. Rev.*, vol. 33, no. 11, Nov. 1930, pp. 608-614, 18 figs. Early type of tube by Roentgen; Jackson's first tube employing focused cathode rays; development of ductile tungsten; tungsten target; manufacture of photomicrograph of crystalline structure of tungsten before and after swaging; hot-cathode tube; types of tubes; heat removal from focal spot; 500,000-volt X-ray tube built in two sections; tubes for very high-voltage X-ray therapy. Abstract of lecture before Am. Roentgen Roy. Soc., Sept. 24, 1930. (To be continued.)

New Books

Available at the Engineering Societies Library

ENGINEERING SOCIETIES LIBRARY
29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

NEW BOOKS AVAILABLE NOVEMBER 1-30, 1930

UNLESS otherwise specified, these books have been presented by the publishers; the Institute assumes no responsibility, all statements being taken from the preface or the text of the book.

A. S. T. M. TENTATIVE STANDARDS, 1930. By American Society for Testing Materials. Philadelphia, The Society, 1930. 864 pp., illus., diagrs., tables, 9 x 6 in., paper. $7.00; cloth, $8.00.——This new edition contains 155 specifications, methods of testing, etc., that have not yet been adopted finally by the Society as standards, but are under consideration, and are offered for criticism. They cover the whole field of engineering materials, there being specifications for various metals, cement, clay products, preservative coatings, road materials, insulating materials, coal and coke, and various other substances.

COMMERCIAL A-C. MEASUREMENTS. By G. W. Stubbings. N. Y., D. Van Nostrand Co., 1930. 325 pp., diagrs., 9 x 6 in., cloth, $6.00.——This book aims to occupy a position between the descriptive treatise and the handbook of test methods. The author omits details of the construction of instruments and confines descriptive matter to that necessary to elucidate the principles of methods, using the space gained for a fairly exhaustive presentation of the theory and practise of the measurement of current, voltage, power, energy, and power factor. Three-phase measurements are treated rather fully. A chapter is devoted to test-room equipment. The work is intended for testing engineers.

GOETHALS, GENIUS OF THE PANAMA CANAL; a Biography. By Joseph Bucklin Bishop and Farnham Bishop. N. Y. and Lond., Harper & Bros., 1930. 493 pp., illus., ports., 10 x 6 in., cloth. $5.00.——A vivid and interesting account of General Goethal's career covers his various activities at West Point, as an army engineer, at the head of the Panama Canal work, and in later life. The work is based on intimate acquaintance and access to many private sources of information, the senior author having been secretary of the Isthmian Canal Commission.

INTRODUCTION TO SURFACE CHEMISTRY. By Eric Keightley Rideal. 2nd edition. Cambridge, Eng., University Press; N. Y., Macmillan Co., 1930. 459 pp., diagrs., tables, 9 x 6 in., cloth. $6.00.——The rapid growth in the study and industrial use of colloidal systems makes desirable an adequate understanding of the properties of surfaces and interfaces. This book aims to review our present knowledge of interfacial systems, in a volume of reasonable size. Students of colloids will find it a valuable introduction to the subject.

KRAFTWERKS-BAUTEN. [2nd edition]. Berlin, Siemens-Schuckert, [Published by V. D. I. Verlag, 1930]. 138 pp., plates, 12 x 8 in., bound. 6. r. m.——A volume of photographs and plans of a number of electric power plants recently built by the Siemens-Schuckert works. The layout and construction of the buildings are considered, not the equipment. Brief data about capacity and equipment are given, with references to more comprehensive published description.

REGELN FÜR ABNAHMEVERSUCHE AN WASSERKRAFTMASCHINEN. 2d edition. Berlin, V. D. I. Verlag, 1930. 8 pp., illus., 12 x 8 in., paper. 1,50 r. m.——These rules for acceptance tests of hydraulic turbines have been formulated by a joint committee of the German associations of engineers and hydraulic interests, with the cooperation of Austrian and Swiss societies. The present revision corresponds to the standards of the International Electrotechnical Commission.

THE SELENIUM CELL; its Properties and Applications. By George P. Barnard. N. Y., Richard R. Smith, Inc., 1930. 331 pp., illus., diagrams, 10 x 6 in., cloth, $9.00.——This valuable monograph aims to present a precise, accurate survey of our knowledge of the properties of selenium and of the applications of selenium cells to photophony, television, talking films and other practical uses. The scattered literature has been very thoroughly summarized and an exhaustive bibliography is included in the book, which will be found most useful by all workers in this field.

STATISTIK FÜR DAS JAHR 1929. By Vereinigung der Elektrizitätswerke. Dortmund, W. Crüwell, 1930. 687 pp., map, 12 x 9 in., boards. 50.-r. m.——An elaborate statistical analysis of the electricity supply of Germany, with data also for a number of power plants in neighboring countries. The data for each plant are very complete and include the information usually wanted as to sources of power, size, efficiency, rates, methods of distribution, equipment, etc.

TABLES ANNUELLES DE CONSTANTES ET DONNÉES NUMÉRIQUES. TABLE DES MATIERES, v. 1-5; 1910-1922. Paris, Gauthier-Villars et cie., N. Y. McGraw-Hill Book Co., 1930. 382 pp., 11 x 9 in., cloth. $20.00——The appearance of this index will be welcomed by all users of the Annual Tables of Constants. It contains analytic, alphabetic, and formula indexes to the material in the first five volumes of the tables, thus making it a simple matter to find what is wanted, and making the set much more useful than it has been.

Local Meetings

Group Activities—What Do They Mean?

When a national organization such as the American Institute of Electrical Engineers is established in a field just coming into being as it was in 1884, its progress over a period of a few years is often phenomenal. The men who had the initiative, spirit and willingness to make the start remain with their shoulders to the wheel, and their enthusiasm is contagious; it spreads without effort, and new members flow into the organization without the necessity of a membership campaign. And, the entire field being of small compass, all are familiar with its various phases, a common interest providing the incentive which keeps the wheels turning.

Years elapse, and the organization grows geographically to become national, and even world-wide. The electrical field is now one of the most complex of its kind, its branches extending from most profound pure science through all the scope of applied sciences. No longer is an all-embracing group possible nor can any one individual master the entire field. Geographical segregation and technical specialization have of necessity crept in and are increasing with time. Groups of men within the big family circle now have interests separate and distinct from those of another division in the field, making for a tendency to break away—to form independent organizations, each devoted to its own local interests and its own specialty.

To take care of this from the geographical standpoint and counteract so far as possible the disadvantage of the hundreds—and even thousands—of miles intervening between centers of activity, the Institute in 1902 approved a plan for the organization of "Sections" in these electrical centers; also for the grouping of engineering students into "Branches" in the universities and technical schools. The step resulted in an immediate rise of the membership curve. In 1919 further effort to give each member opportunity to play his individual part in the progress of the Institute, and to profit by its activities, was evidenced by dividing the country into "Districts" and with a vice-president for each District. Innovations during the following years created various coordinating committees within the Districts and made provision for the payment of certain traveling expenses of delegates. Thus the geographical segregations of the organization knit themselves together. As for the specialization tendency—it, too, has continued to develop, and just so far as conditions would warrant, effort has been made to provide each technical group with papers, sessions, and even meetings, devoted to its specific interests. There was, however, and is, a very definite limit to which this could be carried in time, number of meetings, and finances. Consequently, especially with the larger Sections, lack of interest became evident, and without almost unwarranted effort, good attendance at meetings was difficult to obtain unless meetings included subjects of highly controversial interest or were addressed by effective speakers of national prominence.

Into the picture at this point came the suggestion of "Groups" within the Sections. Chicago and New York immediately put such division into action, New York organizing four groups—Power, Transportation, Communication, and Illumination. So far as possible, execution of plans was placed in the hands of the younger men, who were also expected to provide most of the papers for their group meetings. Free and open discussion at all meetings was encouraged and as expected, the younger men who had never previously been heard at the larger meetings proved eager to prepare papers and take active part in the discussions.

In presenting Group subjects, the effort is always to present a picture comprehensible to those outside a particular field of activity, encouraging the attendance of other groups and broadening the interest. Attendance at Group meetings in New York has frequently equalled, or even exceeded, that formerly registered at general, monthly meetings. But as they appear to be entirely feasible the monthly meetings have continued and there is a strong desire to make such meetings of the widest general interest.

But what has resulted from two years of Group activity? Speaking from the New York point of view—and probably the same applies to Chicago—there has been awakened interest in Section activities. In a city where there are almost endless counter attractions, meeting attendance has increased and is continuing to increase. Men who appeared to have actually passed outside Institute portals have not only come back, but have done so actively, since it is now possible to find here material which they were compelled to acquire elsewhere. The younger man who felt that he had no place in the internal workings of the Institute and who often queried "What do I get out of it?" now feels, and rightly, that he has a new and very real part to play. The New York Section activities have resulted in a greatly increased rate of membership, and have incited men already members to seek advancement to the higher grades, all of which demonstrates a healthy awakening of interest.

The Group movement has apparently solved the tendency to divide and is perhaps the first step toward consolidation.

◆

N. Y. Section Groups to Hold Joint Meeting

Railroad power supply has aroused such wide general interest that the New York Section has arranged a joint meeting of its Transportation and Power Groups to be held on the evening of January 9, 1931. Two papers will be presented:

Power Supply for the D. L. & W. Electrification, by R. D. Booth of Jackson & Moreland, and

Some Business Aspects of Railroad Power Supply, by A. E. Banham of the Public Servic Electric & Gas Company.

Ample time will be allowed for discussion, and anyone interested is cordially invited to participate, even though he may not be affiliated with the New York Section.

The meeting will be held at 7:30 p. m. in Room 1, Engineering Societies Building, 33 West 39th Street, New York, N. Y.

Student Activities an Integral Part of Recent Louisville District Meeting

As parts of the Southern District Meeting in Louisville, Ky., November 19-21, 1930, a student technical session, a conference on student activities, and a luncheon for counselors, chairmen, and other faculty members and students were held.

Technical Session

Professor D. C. Jackson, Jr., chairman, Committee on Student Activities, District No. 4, presided at the student technical session on Thursday morning, which was opened by two brief addresses as follows:

Welcome for the A. I. E. E.
Professor W. S. Rodman, Vice-President, A. I. E. E.

Student Technical Sessions
H. H. Henline, Assistant National Secretary, A. I. E. E.

Mr. Jackson announced that first, second, and third prizes of $25, $15, and $10, respectively, would be awarded by the three judges, Vice-President Rodman, and Messrs. F. M. Craft of Atlanta, and F. H. Miller of Louisville, at the conclusion of the following program presented by students:

The Romance of Television
L. C. Vipond, North Carolina State College of A. & E.

George Westinghouse—A Brief Review of His Life and Career
J. M. Leigh, Mississippi A. & M. College

Theory and Operation of "Deion Grid" Oil Circuit Breakers
Herbert L. Stokes, University of South Carolina

Cooperative Education
John G. Lips, University of Louisville

Student Branch Activities
Russell Ranson, Duke University

Duct-Line and Manhole Construction for Underground Distribution Systems
P. C. Stoll, Georgia School of Technology

An Engineer's Gift to the Invalid
T. C. Brown, University of Kentucky

Lightning Study on Martin Dam-Leeds 110-kv. Transmission Lines
J. C. Evans and H. B. Hendrix, University of Alabama (Presented by Mr. Evans)

Luncheon

The University of Louisville gave a luncheon on Thursday for all counselors, Branch chairmen, and other faculty members and students attending the District Meeting. Professor S. T. Fife, Head of the Electrical and Mechanical Engineering Dept., presided, and Dean B. M. Brigman gave the address of welcome.

In a most interesting and inspiring address, W. S. Lee, president of the A. I. E. E., discussed the great importance of the development of young engineers through the most beneficial kinds of education and practical experience. He then explained in detail some aspects of large engineering construction projects with which he has been connected.

Vice-president Rodman announced the awards for the presentation of student papers at the morning session, and presented prizes as follows:

First: $25, P. C. Stoll, Georgia School of Technology

Second: $15, J. G. Lips, University of Louisville

Third: $10, H. L. Stokes, University of South Carolina

Conference on Student Activities

Professor D. C. Jackson, Jr., chairman of the District Committee on Student Activities, presided at the Conference on Student Activities held Thursday afternoon. As District counselor delegate to the Summer Convention at Toronto, he reported upon the recommendations adopted at the Conference of Officers, Delegates, and Members. He called attention to the parts of the 1930 report on Section and Branch Activities which are of particular interest to Branch officers.

The University of Florida was chosen as the location of the District Conference on Student Activities in 1931, and the consensus of opinion was that it should be held in the Fall Semester.

Professor Joseph Weil, counselor of the University of Florida Branch, was elected chairman of the District Committee on Student Activities, to take office immediately, and also counselor delegate to the Summer Convention in Asheville in June 1931.

Some of the other topics discussed are given below:

Most effective types of programs.
Improvement of attendance at Branch meetings.
Advisability of electric shows by students.
Training next year's officers of Student Branches.
Requirement of personal presentation of papers at Student Technical Sessions.
Aid from the A. I. E. E. in financing research work by students.
Financing the office expenses of the chairman of Student Activities Committee.

A vote of thanks was extended to Professor Jackson for his admirable work as chairman of the District Committee on Student Activities.

Future Section Meetings

Cleveland

January 22, 1931—Future Power Development and Distribution in the Cleveland Metropolitan Area, by H. L. Wallau, Chief Electrical Engineer, Cleveland Electric Illuminating Co.

February 19, 1931—Recent Progress in Communication Technology. Speaker from the Bell Telephone Laboratories, Inc., to be announced later.

Detroit-Ann Arbor

January 20, 1931—Underground Cables, by G. B. McCabe, Detroit Edison Co., and L. F. Hickernell, Allied Engineers, Inc. Meeting at Detroit Edison Auditorium.

February 17, 1931—Detroit Toll Board, by E. C. Balch, Michigan Bell Telephone Co. Meeting at Michigan Bell Telephone Auditorium.

Niagara Frontier

January 16, 1931—Dean Kimball, Cornell University, will speak on Industrial Economics or similar subject.

February 16, 1931—Air Circuit Breakers, by Mr. Gunion, I. T. E. Company.

Seattle

January 20, 1931—Meeting on Communication Engineering by an engineer from the headquarters staff of the Bell Telephone Co.

February 17, 1931—Operating Problems of Trunk Line Electrification, by J. Hawe, Electrical Engineer, Great Northern Railway.

Spokane

January 23, 1931—Predetermination of Transient Stability, by H. V. Carpenter, Dean, College of Mechanic Arts and Engineering, State College of Washington.

Past Section Meetings

Akron

Inspection trip to the electrification and signal system of the Cleveland Union Terminal. Address by H. W. Pinkerton on the electrical and mechanical features of the project, illustrated with films and slides. November 15. Attendance 50.

Atlanta

Inspection trip through the Plant Atkinson Steam Station of the Georgia Power Co. After a buffet supper, provided by that Company, short talks were given as follows:

Georgia Power Company in the Industrial Structure of the State, by W. E. Mitchell, Vice-President, Georgia Power Co.;

Design of Plant Atkinson, by W. P. Hammond, Allied Engineers, Inc.;

Plant Atkinson on the Line, by J. M. Oliver, Georgia Power Co. Joint meeting with the A. S. M. E., attended by students from the Georgia School of Technology. November 24. Attendance 325.

Baltimore

Engineering and Unemployment, by E. C. Stone, Duquesne Light Co., and Vice-President District No. 2, A. I. E. E. Dinner in honor of the speaker preceded the meeting. November 21. Attendance 27.

Boston

Louisiana Power Station of the Louisiana Steam Products, Inc., by Messrs. Weterer, C. R. Stewart, W. L. Locke, and H. J. Klotz. All the speakers are affiliated with Stone & Webster, Inc., and each told of the problems and special features of design that he encountered building this station in the record time of six and one-half months. November 18. Attendance 160.

Cincinnati

The Design and Characteristics of Induction Motors, by Mr. Carter, Allis Chalmers Mfg. Co. This talk included analysis of various designs and examples of their application in industry. General discussion followed. Dinner preceded the meeting. October 9. Attendance 53.

The Use of Electric Industrial Trucks, by C. B. Crockett, Industrial Truck Association. M. R. Berry, Electric Products Co., discussed truck batteries and charging methods. Three reels of motion pictures of electric truck application in large industries were shown. Following the talks, there was considerable discussion on such subjects as truck sizes, maintenance costs, power requirements, battery life, etc. Dinner in honor of the speakers preceded the meeting. November 13. Attendance 80.

Cleveland

High-Voltage Phenomena, by A. O. Austin, Ohio Insulator Co. Preceding this talk, Mr. Austin gave a series of demonstrations of artificial lightning, which he explained in some detail. E. L. Cove, Chief Engineer of Station WHK, gave a short talk on the advisability of insulating radio towers. He explained the advantages of such insulation and described the tests that were being conducted between Station WHK and Station WABC. October 16. Attendance 191.

The Electrical Features of the New Cleveland Terminal, by H. W. Pinkerton, Cleveland Union Terminals Co. Illustrated with slides and motion pictures. H. G. Leavell, Cleveland Electrical League, demonstrated the various lighting effects which can be obtained in their new auditorium. F. W. Braund, Chairman, gave a short résumé of the Summer Convention at Toronto last June. November 20. Attendance 160.

Connecticut

The Electrical Industry and Electrical Engineering in Russia, by A. Dovjikov, Westinghouse Electric & Mfg. Co. Meeting held at Dunham Laboratory, Yale University. November 11. Attendance 100.

Denver

Aerial Tramways, by Fred C. Carstarphen, Consulting Engineer, illustrated by lantern slides and moving pictures. November 21. Attendance 30.

Detroit-Ann Arbor

Lightning Investigations, by H. P. Seeyle, Detroit Edison Co., and J. R. Eaton, Consumers Power Co. Illustrated with slides. Discussion followed. November 18. Attendance 250.

Erie

Annual banquet and ladies' night. Lights of Home, by Ralph W. Shenton. Short address by E. C. Stone, Vice-President, District No. 2, A. I. E. E. Nate Harrington acted as stunt master. Members of the Technical Federation of Erie attended. November 18. Attendance 120.

Fort Wayne

Conduction, Convection, and Radiation of Heat in Electrical Machinery, by Professor A. D. Moore, University of Michigan. November 20. Attendance 100.

Houston

The Aid of the Automatic Telephone in Power Dispatching, by W. B. Hardin, Southwestern Bell Telephone Co. P. N. Underwood outlined the progress made in power transmission over a number of years. Following the the above talks those present visited the dispatching room of the above company, where the system was thoroughly explained and demonstrated. November 25. Attendance 30.

Indianapolis-Lafayette

Moving the Indiana Bell Telephone Company's Headquarters Building, by Vance Oathout, Indiana Bell Telephone Co.;

Latest Developments in Television, by Professor R. H. George, Purdue University. Also two films presented as follows: "Blasting the Water Highways of America," and "Hydroelectric Developments in the New South." Joint meeting with the Indiana Section of the American Radio Relay League. Dinner preceded the meeting. November 29. Attendance 105.

Los Angeles

F. E. Weymouth, Metropolitan Water District, gave an illustrated lecture concerning the proposed routes for the aqueduct through which the supply of water for Southern California from the Colorado River is to be effected. General discussion followed. Joint meeting with the A. S. C. E., the A. S. M. E., and A. I. M. E. November 12. Attendance 402.

Louisville

Meeting held to discuss plans for the District Meeting at Louisville. November 12. Attendance 40.

Memphis

The Electrification of Dredges, by C. T. Pearce, Westinghouse Elec. & Mfg. Co. R. H. Maxwell, of the same company, demonstrated the Grid-Glow Tube, Photoelectric Cell, and accessory equipment. November 12. Attendance 35.

Mexico

Annual banquet at which the officers for the year 1930-1931 were announced and introduced. November 22. Attendance 53.

Nebraska

Modern Practise of Laying Underground Long Distance Cables, by F. J. Rupe, Northwestern Bell Telephone Co., illustrated with moving pictures showing construction work in progress. November 21. Attendance 40.

Niagara Frontier

Mercury Arc Rectifiers, by Othmar K. Marti, American Brown Boveri Co., illustrated with slides. Motion pictures describing the mining, smelting, refining and rolling of the metal were presented. November 21. Attendance 60.

Oklahoma City

The World Power Conference at Berlin, Germany, by Dean P. S. Donnell, Oklahoma A. & M. College, illustrated with a number of slides made from pictures taken while visiting Europe. Film—"The New Hydroelectric Generating Station at Louisville, Ky." October 30. Attendance 115.

Illumination, by A. E. Warner, Oklahoma Gas & Electric Co.;

The Installation and Operation of Underground Toll Cable, by M. L. Olsen, Southwestern Bell Telephone Co. Illustrated with four films showing the actual installation of several underground toll cables in the southwest. November 24. Attendance 82.

Philadelphia

Some Recent Research Developments, by E. L. Manning, General Electric Co. November 10. Attendance 200.

Pittsburgh

Modern Physics, by Saul Dushman, General Electric Co. Moving pictures preceded the presentation of this paper. Joint meeting with the Engineers' Society of Western Pennsylvania. November 12. Attendance 324.

Pittsfield

Recent Developments in Steam Turbines, by H. L. Wirt, General Electric Co. Illustrated with slides. Dinner preceded the lecture. November 18. Attendance 120.

India—Present Condition and Future Outlook, by Professor S. L. Joshi, Dartmouth College. Dinner preceded the meeting. December 2. Attendance 550.

St. Louis

Dance. November 15. Attendance 132.

San Antonio

The Development of Radio Broadcasting, by J. Cummings, Manager of WOAI Broadcasting Station. Following the meeting those present inspected Station WOAI and Mr. Cummings gave brief explanations of the functions of each part of the station apparatus. November 17. Attendance 68.

San Francisco

Telegraphing Today, by M. V. Merriman, Western Union Telegraph Co. Miscellaneous apparatus, consisting of relays and parts from the various equipment used in telegraph, on display. Following the meeting the members were conducted through the main office of the Western Union Telegraph Co. The exchange was in full operation and all had an opportunity of witnessing the various activities as they normally take place. November 28. Attendance 90.

Saskatchewan

Some Recent Developments in Transformer Design, by C. E. Sisson, Canadian General Electric Co., and Vice-President District No. 10, A. I. E. E. Illustrated with a number of lantern slides. October 20. Attendance 22.

Seattle

Some Fundamentals of Illumination—Old and New, by Professor F. A. Osborn, University of Washington. Two moving pictures followed. A report of the Summer Convention held in Toronto last June was presented by L. N. Robinson, who was the delegate of the Section. November 18. Attendance 60.

Sharon

Semi-Annual Winter banquet meeting. Humor—A Mental Cocktail, by Dr. John L. Davis. December 2. Attendance 180.

Spokane

Spokane River Flow Control for Economic Operation of Hydroelectric Plants, by John A. Tobyn, Washington Water Power Co.;

Motors and Their Application, by Henry L. Vincent, General Electric Co. A report of the Summer Convention at Toronto last June was given by Earl Baughn, who was the delegate of the Section. November 21. Attendance 25.

Springfield

A Mechanical Analogy to the Problem of Transmission Stability, by A. D. Dovjikov, Westinghouse Elec. & Mfg. Co. Refreshments served after the meeting. November 10. Attendance 54.

Toledo

Metal-Clad Switch-Gear, by H. V. Nye, Allis Chalmers Mfg. Co., illustrated with slides. E. B. Featherstone presented a film "A Tourist Trip Through The Rockies," and explained the scenes as they appeared. November 14. Attendance 70.

The Transmission of Personality, by L. S. O'Roark, Bell Telephone Laboratories, Inc. Dinner meeting of the Affiliated Technical Societies of Toledo. December 4. Attendance 275.

Toronto

Copper Mining, Smelting, and Manufacture, by G. S. Mallett, American Brass Co. Moving pictures describing the mining, smelting, and fabricating of copper were presented. November 14. Attendance 88.

Planning to Meet the Development of the Systems of the Hydroelectric Power Commission of Ontario, by A. H. Frampton, H. E. P. C., illustrated with slides. November 28. Attendance 83.

Urbana

The Universe as a Physical Laboratory, by Professor R. H. Baker, Head of the Department of Astronomy, University of Illinois. November 18. Attendance 30.

Utah

Domestic Electric Water Heating, by H. M. Ferguson, Utal Power & Light Co. Informal dinner preceded the meeting. November 10. Attendance 40.

Washington

The Work of the American Engineering Council, by L. W. Wallace, American Engineering Council. Dinner preceded the meeting. November 11. Attendance 46.

Worcester

Construction and Maintenance of the 15 Mile Falls Development of the New England Power Company, by C. R. Olliver, illustrated with slides. November 13. Attendance 60.

Past Branch Meetings

University of Akron

Deion Circuit Breakers, by Mr. Seified, Student. Professor J. T. Walther, Counselor, and H. Shively, Chairman, outlined the activities at the District Meeting held in Philadelphia. October 30. Attendance 11.

Transmission Problems on Long Lines, by Troy Starr, American Tel. & Tel. Co. November 21. Attendance 11.

University of Arkansas

Railway Electrification, by G. V. Smith, Student;

Television, by Robert Hunt, Student. An automatic relay was presented to the school by Wylie Head, who had received it as a trophy of his summer work with the Westinghouse Elec. & Mfg. Co. November 5. Attendance 24.

Armour Institute of Technology

Radio as an Aid to Police, by W. P. Hilliard, Chicago Police Department. Joint meeting with the Armour Radio Association. November 17. Attendance 89.

Discussion on Submarine Tele-

Phones and Telegraph Cables, by Donald M. Detterman, Student;

High-Frequency Radio Beam Transmission, by Morton Fagen, Student. December 1. Attendance 51.

University of British Columbia

The Cathode Ray Oscillograph, by E. Crawford, Student;

Mercury Arc Rectifiers, by Mr. Thomas, Student. November 18. Attendance 17.

Inspection trip to the Ruskin hydroelectric plant of the British Columbia Electric Railway. November 21. Attendance 22.

Polytechnic Institute of Brooklyn

Electrodynamometers for Power Measurement, by T. C. Katsigris, Hub Engineering Corp;

Photelectric Cells, Their Construction and Uses, by R. T. Orth, Radio Corporation of America;

Lightning on Transmission Lines, by Prof. V. Karapetoff. Refreshments were served after the meeting. November 10. Attendance 64.

Bucknell University

Conowingo Hydroelectric Development on the Susquehanna, by C. M. Deatherage, Student;

The Philadelphia Plant of the General Electric Co., by Leighton Herbst, Student. O. R. Sterling, Chairman, outlined the activities of the Institute. November 10. Attendance 12.

California Institute of Technology

The Electrical Equipment of the New Astro-Physics Laboratory, by Emmett M. Irwin, Student. Luncheon preceded the meeting. November 20. Attendance 40.

University of California

After a short business meeting the following papers were presented:

Power, by A. H. Markwart, Pacific Gas & Electric Co.;

Hydroelectric Power Developments in California, by Robert W. Hollis, Student. November 19. Attendance 69.

Business meeting followed by the presentation of two films, as follows:

"The Steel Needle," and "Conquering the Cascade." New officers were announced and introduced. December 3. Attendance 25.

Catholic University of America

Election of officers as follows: David F. Doody, Chairman; C. R. Liekweg, Vice-Chairman; F. D. Vezzosi, Secretary-Treasurer. Professor T. J. MacKavanagh, Counselor, gave a talk on the activities of the Institute. October 11. Attendance 30.

The Photoelectric Cell and Its Applications in Industry, by D. F. Doody, Student. November 11. Attendance 30.

Clarkson College of Technology

Lecture on Photography, by Assistant Professor W. A. Dart, illustrated. Committee reports presented. November 11. Attendance 13.

Inspection trip to the Alogonquin Paper Corporation's Mill at Ogdensburg, N. Y. November 12. Attendance 51.

Clemson College

Inspection trip to the Saluda River Hydroelectric Power Plant. October 22. Attendance 35.

General Power Applications, by A. T. Vick, Student;

Two-Way Television, by H. C. Woodson, Student;

Current Events, by C. B. Stevens, Student; November 20. Attendance 26.

Report of the District Meeting in Louisville, by C. E. Jarrard, Student;

Current Events, by Joe Vance, Student. December 4. Attendance 30.

Colorado Agricultural College

Electrification of Rural Districts, by Mr. Stanbaugh, Public Service Co. of Colorado. November 24. Attendance 18.

University of Colorado

Rambles Through the Rockies, by Eben Fine. Illustrated. November 19. Attendance 30.

The Community and the Engineer, by Herbert S. Sands, President, Denver Chamber of Commerce. Professor Frank A. Eastom gave a short talk on the Summer Convention in Toronto last June. Professor Charles M. McCormick discussed the meetings held by the Denver Section. December 3. Attendance 35.

Cooper Union

Film—"The Theory of Construction and Operation of Electrical Instruments." November 19. Attendance 60.

Cornell University

Radio Beacon, by H. B. Simpson, Student;

Public Address Systems, by A. C. Stallman, Student;

Calculating Boards, by P. J. Glaister, Student;

The Charles Huntley Generating Station, by L. A. Eggelston, Student. December 3. Attendance 30.

Drexel Institute

Demonstration and Explanation of the Theremin, by Fred Farrow, Radio-Victor Corp. November 25. Attendance 60.

Duke University

L. R. Ransom, President, outlined the purposes and aims of the Institute. A. L. deBruyne elected Secretary. October 5. Attendance 17.

The Photoelectric Cell and Some Applications, by Russell Ransom, President;

Television and Recent Developments in that Field, by Stanley G. Flack, Student;

The Condenser Microphone and the Theory of It, by A. L. deBruyne, Secretary. Professor W. J. Seeley, Counselor, urged all to take an active part in the A. I. E. E. activities. October 16. Attendance 30.

Mercury Arc Rectifiers, by C. F. Brethal, Student. October 30. Attendance 10.

Illumination, by R. L. Peppell and W. F. Weaver, Students. November 13. Attendance 18.

University of Florida

A Trip through the Inglis Power Plant of the Florida Power Corporation, by J. L. Wolcott, Student;

A Modern Explanation of the Ohm's Law, by J. L. Sanders, Student. Film—"Hydroelectric Power Production in the New South." November 17. Attendance 22.

Reports of the recent District Meeting held in Louisville were given by Professor Joseph Weil, Counselor, and C. V. Booth, Chairman. December 3. Attendance 37.

Georgia School of Technology

Steam-Turbine Developments and Principles of Operation, by P. C. Eppelshimer, Westinghouse Elec. & Mfg. Co. November 12. Attendance 71.

Inspection trip to Plant Atkinson of the Georgia Power Company. Joint meeting with the A. I. E. E. and A. S. M. E. Sections. November 24. Attendance 100.

Harvard University

The Fifteen Mile Falls Hydroelectric Development, by E. W. Dillard, New England Power Construction Co., illustrated with lantern slides and motion pictures. November 13. Attendance 180.

State University of Iowa

The Automatic Garage, by Mr. Colony, Student;

Telephones in the Rough, by Mr. Cutler, Student;

Sound Reproduction, by Mr. Duckett, Student. November 19. Attendance 29.

Practical Uses of the Photoelectric Cell, by Mr. Fitzgerald, Student. Professor Edwin Kurtz, Counselor, and J. W. Campian, Chairman, gave reports of the Conference on Student Activities held in Chicago. December 3. Attendance 33.

Kansas State College

Success, by Professor L. M. Jorgenson. Professor R. G. Kloeffler, Counselor, gave a talk outlining the purposes and aims of the A. I. E. E. Entertainment and refreshments followed. October 24. Attendance 180.

Current Events, by S. W. Graham, Student;

Opportunities in Public Utility Work, by Paul Ayers, Student;

Television, by Mr. Burgin, Student. Moving pictures on the subject of X-rays presented. (Afternoon session.) October 30. Attendance 54.

The program of the evening meeting was the same as that presented in the afternoon. October 30. Attendance 53.

Current Events, by W. Tolley, Student;

Photoelectric Cells and Their Applications, by K. D. Cornell, Student;

L. E. Baldwin, Kansas Power & Light Co., gave a talk on public utility work and its functions, and also the possibilities for college graduates with these companies. Film—"Thomas Edison." (Afternoon session.) November 6. Attendance 56.

The program of the evening meeting was the same as that presented in the afternoon. November 6. Attendance 55.

University of Kansas

Television, by C. B. Brown, Student. Demonstrated.

Reports of inspection trips to Keokuk, Chicago, Milwaukee, and other cities by several students. November 13. Attendance 77.

Some Mechanical Engineering Problems in a Modern Oil Refinery, by W. L. Mathews, Standard Oil Co.;

Some Construction Details of an Industrial Power Plant, by C. O. Boynton, Standard Oil Co.;

Toll Telephone Plant Construction, by J. H. Schweitzer, Southwestern Bell Telephone Co., illustrated with slides;

Economic Design of Inter-City Communication Facilities, by L. F. Burwick, Southwestern Bell Telephone Co. Joint meeting of the Kansas City Sections and Univ. of Kans. Branches of the A. I. E. E. and A. S. M. E. December 4. Attendance 175.

University of Kentucky

Power of the East River Generating Station, by C. O. Fury, Student;

Power of the Pacific Light and Power Company, by F. Y. Carter, Student;

Membership Qualifications, Grades, and Entrance Requirements of the A. I. E. E., by Professor W. E. Freeman, Counselor. October 18. Attendance 41.

Scientific Aspects of Thomas Jefferson's Life, by Professor W. S. Rodman, Vice-President, District No. 4, A. I. E. E. November 17. Attendance 45.

Nitrogen Fixation Process, by S. H. Wise, Student;

W. O. Richmond, Student, gave a summary of a new method of removing water from the tanks of submarines. December 3. Attendance 41.

Lehigh University

Applying an Engineering Education, by H. G. Harvey, Associated Gas & Electric Co.;

The Screen-Grid Radio Circuit, by L. R. Wanner, Student. Paul W. Seal, Chairman, outlined the proposed program for the coming year; also the aims and activities of the A. I. E. E. November 7. Attendance 100.

Lewis Institute

Your Chicago, by T. Price, Commonwealth Edison Co., illustrated with moving pictures. December 5. Attendance 76.

Marquette University

Short papers read by several students. November 13. Attendance 22.

Massachusetts Institute of Technology

The Generation and Distribution of Electric Power, by E. S. Mansfield, Edison Electric Illuminating Co. of Boston. Film—"More Power To You." November 20. Attendance 230.

Inspection trip to the Milk Street Manual Exchanges and the Kenmore Automatic Exchanges of the New England Telephone & Telegraph Co. December 3. Attendance 30.

Michigan College of Mining and Technology

Motor Maintenance and General Maintenance of Electrical Equipment, by Mr. Zimmerman, Westinghouse Elec. & Mfg. Co. Committees appointed to take care of the arrangements for the Electrical Show to be held next May. November 7. Attendance 61.

The Student Training Course at Westinghouse, by M. D. Crowell, Secretary. November 19. Attendance 29.

James Rowley, Student, outlined his experiences with the Detroit Edison Co. during the past summer. December 3. Attendance 25.

University of Michigan

What Does an Engineer do in a Manufacturing Plant, and How? by A. M. Dudley, Westinghouse Elec. & Mfg. Co. November 12. Attendance 100.

The Production of Electric Power, by A. R. Smith, General Electric Co. November 18. Attendance 110.

School of Engineering of Milwaukee

The Water Supply of Muncipalities and the Selling of Water Supply Equipment, by E. Roger, Layne-Northwest Pump Co. Refreshments served. November 12. Attendance 150.

Missouri School of Mines and Metallurgy

The Effect of Electricity upon the Nervous System, by J. E. Stokes, Student;

My Summer Experiences, by A. R. Baron, Student. November 19. Attendance 21.

My Summer Experiences, by J. D. Shelton, Chairman. December 3. Attendance 13.

University of Missouri

Design of Alternators, by J. W. Logan, Student. November 12. Attendance 57.

Montana State College

A Small Motor with a Low Starting Current, taken from the *Electric Journal*, presented by Wesley C. Funk, Student;

A New Portable Oscillograph, taken from the A. I. E. E. Journal, presented by Manley Goldberg, Student;

The Development of the Modern X-Ray Generating Apparatus, taken from the *General Electric Review*, presented by N. Grebeldinger, Student. November 6. Attendance 147.

Electricity vs. Steam, taken from *World's Work*, presented by Arthur Sheldon, Student;

Short Cuts in Mathematics, by Walter Williams, Student;

A Portable Emergency Local Distribution Substation, taken from the *General Electric Review*, presented by Harry Beck, Student;

Scheduled Speed Increased by Electrification, taken from the *Electric Railway Journal*, presented by Howard Freeman, Student. November 13. Attendance 145.

N. E. L. A. Electrification Report, taken from *Railway Age*, presented by Vern Hankins, Student;

Radio now has Tone Control, taken from *Popular Science Monthly*, presented by Curtis Hanson. November 20. Attendance 146.

University of Nebraska

What I would do if I were a Senior now, by F. J. Gunther, Iowa-Nebraska Light & Power Co. December 3. Attendance 30.

Newark College of Engineering

Electrification of the Lackawanna, by Edward Anson, Jackson & Moreland;

Development of Mercury Arc Rectifiers, by W. R. Ackor, Chairman, illustrated. November 17. Attendance 41.

University of New Hampshire

Retox Rectifiers, by Marshall E. Bowker, Student;

Multiplex Printers, by Arthur G. Pinkham, Student. October 18. Attendance 34.

Film—"Power Transformers." November 15. Attendance 33.

Theory of Corona Loss in Power Transmission, by C. G. Matoian, Student;

Demonstration of the Left-Hand Motor Rule, by R. E. Sawyer, Student;

Horn-Gap Lightning Arrestep, by A. G. Pinkham, Student. L. E. Potts and L. E. Moore, Students, demonstrated the above with high-voltage apparatus, and conducted a few other experiments with the same apparatus. November 22. Attendance 24.

Some Hydroelectric Developments in New Hampshire and Vermont, by P. E. Rolfe, Student;

Manufacture and Uses of Carborundum, by L. A. Barker, Student;

Sparking in a Partial Vacuum, by M. H. Riley, Student. November 29. Attendance 30.

University of New Mexico

The Radio Knife, by C. E. Henderson, Chairman. November 13. Attendance 15.

New York University

Debate—Resolved: That water power in New York States be Owned, Operated, and Distributed by the State. November 10. Attendance 21.

Tying Up of Power Networks, by C. J. Ridgley, Student. November 24. Attendance 14.

North Carolina State College

Review of the Life of Steinmetz, by C. M. Smith, Student;

Railroad Signaling, by J. W. Sutherland, Student. November 18. Attendance 31.

A report of the District Meeting held at Louisville was given by R. C. Kirk, Chairman. December 2. Attendance 30.

North Dakota State College

Film—"Power." November 20. Attendance 85.

Film—"From Coal to Electricity." December 4. Attendance 52.

University of North Dakota

A New Screen-Grid Tube, by William Denk, Student;

William Spriggs and A. W. Eynon, Students, gave a practical demonstration of the current-illumination characteristics of the photoelectric cell, and also its color sensitivity. November 12. Attendance 18.

Northeastern University

Electrical Units, by Dr. A. E. Kennelly, Harvard University. Refreshments served. November 4. Attendance 89.

University of Notre Dame

The Street Lighting System of South Bend, Indiana, by Frank Mills, Indiana Michigan Electric Co.;

Starting and Reversing Single-Phase Induction Motors, by John Staunton, Student;

High-Frequency Induction Furnaces, by A. White, Student;

Patrick Murray, Student, presented the regular digest of engineering news. November 17. Attendance 73.

Ohio Northern University

The Effect of Electric Shock, by J. M. Stewart, Student. November 20. Attendance 33.

Ohio University

Films as follows: "Beyond the Microscope," "Pillars of Salt," and "The Continuous Process of Making Sheet Steel." November 17. Attendance 12.

Oklahoma A. & M. College

Construction and Care of Transformers, by W. E. Nichols, Student;

Evolution of the Transformer, by Hubert Short, Student, illustrated with slides. November 20. Attendance 10.

Oregon State College

General discussion of Branch activities. November 10. Attendance 55.

Electric Power from Hogged Fuel and the Relation of Steam to Water Power Plants, by C. P. Osborne, General Electric Co., illustrated with slides. Films—"Blasting the Water Highways of America," and "Hydroelectric Power Production in the New South." November 19. Attendance 38.

Pennsylvania State College

Smoker and Annual Get-Together. October 8. Attendance 91.

Talks by five Students on their summer experiences. October 29. Attendance 38.

Film—"From Mine to Consumer." November 5. Attendance 53.

The Development Engineer in Manufacture, by D. Levinger, Western Electric Co., illustrated with slides and motion pictures. November 18. Attendance 93.

University of Pennsylvania

Motion pictures. December 5. Attendance 26.

University of Pittsburgh

Lightning, by R. G. Woessner, Student;

H. K. Aalborg, Student, related his experiences as circuit breaker engineer while employed by the Westinghouse Electric & Mfg. Co. October 9. Attendance 116.

Transoceanic Communication, by R. A. White, Student;

D. N. Burdette, Student, outlined the design and operation of magnetic strain gages as developed by the Westinghouse Electric & Mfg. Co. October 16. Attendance 110.

Biography of Faraday, by Robert Canning, Student;

D. W. Burns, Student, outlined some early developments in electricity. October 23. Attendance 109.

Modern Railways, by C. I. Staples, Westinghouse Elec. & Mfg. Co. Movies, refreshments, and entertainment followed. October 30. Attendance 85.

H. J. Stoneman, Student, described the operation of the West Penn Power Company's Coal Mine at Springdale;

W. J. Wherry, Student, outlined the manufacture of rubber as carried on at Akron, Ohio. November 6. Attendance 113.

Modern Electric Refrigeration, by A. J. Mattes, Student;

F. A. Mallisee, Student, traced the historical development of all types of meters. November 13. Attendance 113.

Development of Transmission Lines, by L. A. Terben, West Penn Power Co. November 20. Attendance 118.

Pratt Institute

Panel Boards, by L. Johnson, Student;

Railroad Control and Railway Signaling, by C. Schimke, Student. November 13. Attendance 30.

Westinghouse Test, by John Cook, Student. December 3. Attendance 50.

Princeton University

Election of officers as follows: Frank L. Thomson, Chairman; E. E. George, Secretary. December 4. Attendance 13.

Purdue University

Lecture on the Magnetic-Type Oscillograph, by Professor G. V. Mueller;

New Permanent-Magnet-Type Oscillograph, by D. A. MacAffer, General Electric Co. November 20. Attendance 125.

Rensselaer Polytechnic Institute

Description of the Emmet Mercury Vapor Process equipment installed by the General Electric Co. in the South Meadows station of the Hartford Electric Co., by James Orr of the same company. November 11. Attendance 285.

Rhode Island State College

Film—"Buried Sunshine." November 24. Attendance 30.

Business Meeting. December 8. Attendance 7.

Rose Polytechnic Institute

Film—"A History of the Electrical Industry." November 24. Attendance 37.

Lifting Magnets, by Mr. Richardson, Student;

Robert Roach, Student, gave a report of the Conference on Student Activities held in Chicago. December 5. Attendance 34.

Rutgers University

Recent Developments in the Bell System, by Mr. Birch, Student;

Opportunities for Employment in the Bell Laboratories, by Mr. Wolff, Student. October 28. Attendance 22.

Rubber-Covered Cables, by Milton Trompen, Student;

Film—"The Single Ridge." November 11. Attendance 25.

Kenotron and Thyratron Tubes, by Jacob Rudnitsky, Student;

Rotary Converters, by Fred Kent, Student;

Comments on Mercury Arc Rectifiers, by Prof. Pumphries. November 24. Attendance 19.

Santa Clara University

Films"—Hydroelectric Water Tunnels," and "Channel Excavations." November 5. Attendance 31.

Survey of Aeronautics, by Walter Van Haitsma, Boeing Aircraft Co. November 19. Attendance 63.

Oil Circuit Breakers, by Roy Wilkins, Pacific Electric Mfg. Corp., illustrated with slides. November 19. Attendance 40.

Inspection trip to Station A—Pacific Gas & Electric Co. Generating Plant. November 24. Attendance 39.

University of South Carolina

The Deion Circuit Breaker, by H. L. Stokes, Chairman. Film—"Hydroelectric Power Production in the New South." November 17. Attendance 34.

The Engineer's Outlook on Life, by S. Hammon. Professor T. F. Ball, Counselor, and H. L. Stokes, Chairman, outlined the events at the District Meeting held in Louisville. November 24. Attendance 30.

Business Meeting. December 1. Attendance 9.

South Dakota State School of Mines

Needed Improvements in Distribution Systems, by Lee Boyer, Consolidated Power & Light Co. Stanley Sickle and Clifford Spilker, Students, outlined their experiences during the past summer on construction work with the American Tel. & Tel. Co. November 19. Attendance 34.

University of Southern California

Lecture on The Trails of the High Sierra, by Professor N. C. Clark, illustrated. November 29. Attendance 45.

Lecture by Professor N. C. Clark on the region near and including Yosemite Valley. November 5. Attendance 37.

Films—"Blasting the Water Ways of America," and "Hydroelectric Power Production in the New South." November 12. Attendance 34.

Industrial Lighting, by Willard Bausman, Holophone Illuminating Co. November 19. Attendance 31.

Blind Landing of Aeroplanes, by Walter Weis, Student. December 3. Attendance 25.

Southern Methodist University

Professor H. F. Huffman, Counselor, outlined the aims and activities of the Institute. Election of officers as follows: F. H. Gable, Chairman; I. Frauman, Vice-Chairman; Porter Lindsley, Jr., Secretary-Treasurer. October 15. Attendance 37.

Underground Distribution System of the Dallas Power & Light Co., by H. H. Robinson of the same company. Illustrated. November 12. Attendance 30.

Demonstration of a Short-Wave Sending Set, by D. J. Tucker, Student;

Demonstration of a Thermocouple, by R. L. Allen, Jr.;

Laboratory Experiments with Transformers, by Carlos Burnett, Student. Joint meeting with the Dallas Section. November 17. Attendance 80.

Stanford University

E. A. Crellin, Vice-Chairman, San Francisco Section, A. I. E. E., discussed plans for closer relationship between the Branches and the Section. Professor T. H. Morgan, Counselor, outlined the new by-laws concerning Student enrolment. October 21. Attendance 17.

Aeronautical Radio Communication, by Eugene Sibley, reviewed by Robert Triplett, Student;

Relay Metering, by D. A. Murray;

A New System of Speed Control for A-C. Motors, by A. M. Rossman, reviewed by V. Siegfried, Chairman;

G. S. Kimball, Student, described the new equipment being installed in the Electrical Engineering Laboratory. November 25. Attendance 15.

Syracuse University

Trolley Buses, by E. W. Schweitzer, Student;

Automatic Train Control, by D. W. Phelan, Student. November 14. Attendance 25.

Recording of Sound Pictures, by M. J. Kraska, Student;

Airport Lighting, by C. R. Anderson, Student. Illustrated. November 21. Attendance 25.

Two illustrated lectures presented as follows: The Evolution of the Transformer, and 50,000 Kv-a. Synchronous Condensers. December 5. Attendance 25.

University of Tennessee

Get-Together Meeting. December 2. Attendance 52.

Texas A. & M. College

Electric Shock, by H. A. Eddins, Student;

Resuscitation from Electric Shock, by J. A. Shellberg, Student. November 11. Attendance 60.

Texas Technological College

Dean W. J. Miller, Counselor, and Walter Burns, Chairman, outlined the aims and purposes of the Institute. Committee appointments announced. October 8. Attendance 19.

Film—"The Conowingo Hydraulic Dam." November 7. Attendance 14.

The Adapting of Electricity to Railroads and Large Ships, by Wm. Walker, Student;

Tuco (a large generating plant which is nearing completion), by Hulbert J. Allen, West Texas Utility Co. November 19. Attendance 50.

Inspection trip to the new power plant of the Texas Utility Co. November 25. Attendance 35.

University of Texas

Boiler Feed-Water Control, by C. A. Glover, Student. November 13. Attendance 18.

University of Utah

New Developments in Hydroelectric Plants, by L. E. Painter, Student;

The Relationship between the Big Open Air Mine at Bingham, Utah, and Electricity, by Ray Bohne, Student. October 28. Attendance 21.

Film—"From Mine to Consumer." December 2. Attendance 24.

University of Vermont

Westinghouse Method of Frequency Control, by P. H. Thomas, Student;

The Selsyn Motor, by M. L. Joslin, Student. November 18. Attendance 27.

Films as follows: "Blasting the Water Highways of America," "Building New York's Newest Subway," "Driving the Cascade Tunnel," and "Hydroelectric Power Production in the New South." Joint meeting with the A. S. M. E. December 3. Attendance 60.

Virginia Military Institute

Improved Lighting on Our Highways, by Mr. Ould, Student;

Industry's Tribute to George Westinghouse, by Mr. Woodson, Student;

Railroad Electrification, by Mr. Moore, Student;

The Talking Picture Apparatus in J. M. Hall, by Mr. Stokes, Student;

Low Cost of Construction, by Mr. Welch, Student. October 16. Attendance 47.

An account of the activities of the District Meeting held in Louisville was given by C. G. King, representative of the Branch. December 4. Attendance 47.

Virginia Polytechnic Institute

Professor C. Lee, Counselor, and R. E. McDaniel, A. B. Pritchard, and E. L. Rowell, Students, outlined the activities of the District meeting held in Louisville. November 25. Attendance 17.

Steinmetz, by R. C. Hoffman, Student;

Sound Reproduction, Western Electric Method, by W. J. Pritchard, Student;

Economy and the Engineer, by C. V. Burgess, Student. Professor C. Lee, Counselor gave a talk on some of the activities of the Institute. December 4. Attendance 42.

University of Virginia

Development of Short-Wave Radio Communication, by W. B. Campfield, Student;

Development of Broadcast Radio, by G. B. Miller, Student. Short talk by Professor W. S. Rodman, Counselor. November 7. Attendance 16.

Washington State College

Film—"An Electrical Travelogue." November 12. Attendance 36.

Harry Skaglund, Student, outlined a trip he took to Diablo Dam, near Seattle, last summer. Committee chosen to make arrangements for the A. I. E. E. banquet. November 25. Attendance 16.

University of Washington

Switchboard Equipment, by James MacDougal, Roller Smith Co., illustrated with slides. November 6. Attendance 20.

The Power Company's Goat, by P. L. Morton, Student. November 13. Attendance 23.

Washington University

Radio Servicing, by Richard O-Denning, Student. November 6. Attendance 26.

Electrical Communications, by J. C. Rathman, Postal Telegraph Co. Film—"Under the Seven Seas." November 20. Attendance 17.

University of Wyoming

Rectifiers used in Radio Apparatus, by Floyd Wickencamp, Student;

Effect of Anti-Knock Compounds on Fuels Used in Internal Combustion Engines, by Vincent Bowles, Student. Joint meeting with the A. S. M. E. November 4. Attendance 17.

Electric Fish, by E. Hemenover, Student;

A New Method of Removing Scale and Corrosion from Steel, by J. Sillasen, Student;

Power from the Ocean, by C. Horton, Student. November 18. Attendance 11.

Yale University

Advantages and Disadvantages of Holding Corporations, by R. A. Hockley, Student;

Regulation of Holding Companies, by E. R. Eberle, Student;

The General Electric Unemployment Insurance Plan, by L. A. Autuori, Student. November 18. Attendance 13.

Power System Stability, by Professor G. C. Dahl, Massachusetts Institute of Technology. November 25. Attendance 42.

Employment Notes

Of the Engineering Societies Employment Service

Positions Available

SALES ENGINEER, who has had experience selling resistance units and rheostats for industrial and radio applications. Apply by letter giving experience in full. Headquarters, Middle West. W-2120.

◆

Men Available

ELECTRICAL ENGINEER, college graduate, good character. Approximately 13 years' practical experience divided as follows: 9 months' clerical work, 6 months maintenance and switchboard operating in high tension power plants, 12 years' detailed and general engineering of low voltage power plants. C-8328.

1930 GRADUATE ELECTRICAL ENGINEER, Rensselaer Polytechnic Institute. Ten months' experience with sound picture industry; five months' thesis experience investigating acoustics of broadcasting studio, miscellaneous experience servicing radio receivers. Location, New York City district. Available short notice. C-8407.

ELECTRICAL SUPERINTENDENT OR FOREMAN, 12 years' experience taking charge; can handle any size job or jobs. Sober, reliable and industrious. Best of references. C-8464.

1929 GRADUATE, American, E. E. degree: 14 months on General Electric Test Course. Interested in research; vacuum tube application work. Experience covers above, also testing all types of electrical equipment. C-1879.

ENGINEER, EXECUTIVE, B. S. degree; 20 years' experience in engineering, contracting and purchasing, desires permanent connection with large industrial company or as a local representative. Location, New York City. B-5050.

ELECTRICAL ENGINEER, 27. Experience includes: Westinghouse oscillograph operation; raw material inspection; pump, boiler and steam turbine tests; electrolysis survey of subway cables; electrical construction in finished buildings. Laboratory work preferred in Metropolitan area. C-8424.

GRADUATE ELECTRICAL MECHANICAL ENGINEER, 36, desires connection with public utility, industrial firm in power station operation as engineer, assistant to superintendent or engineer. Ten years' experience power plant test, operation, design, construction, maintenance. Three years electrical engineer for industrial concern. Two years assistant to power engineer. B 8379.

1930 GRADUATE ELECTRICAL ENGINEER, 22. Experience: six months in boiler-testing gang, three months testing centrifugal

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
A. K. Krauser, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

water pumps, one year maintaining test equipment in radio receiver manufacturing plant. Prefers work in radio, sound reproduction, or communication; however, will be interested in other work. Location, preferred in or near New Jersey. C-8452.

ELECTRICAL ENGINEER AND EXECUTIVE, married; 20 years' experience in electric distribution and maintenance problems. Desires position in East or South with public utility company. Available immediately. C-7700.

ELECTRICAL ENGINEER, 28, single, B. S. in E. E. 1924. Six years' experience large public utility in utility economics including water power values, financial, load forecasts, power studies, studies of system development, rate studies, unit costs, research work, general matters of financial, economic nature; desires position, public utility, industrial concern. Location, preferably South. C-6985.

GRADUATE ELECTRICAL ENGINEER, 34, married, desires connection with future. Experienced in power and substation work, investigations, estimates, specifications, design and construction, control and relay work, related calculations, investigation of system conditions in connection with expansion and load additions. Industrial substations. Foreign languages. U. S. Citizen. Location, United States or Foreign. B-6560.

ENGINEER, with sales experience over a wide territory and experienced in electrical, mechanical and rubber industries in development laboratory and production. Offers his services. B-7829.

SALES ENGINEER, 27, single, graduate engineer. Engineering and sales experience of five years with leading control manufacturer. Desires position with sales department of an electrical concern or motor-control specialist for a fast growing electrical jobbing house. C-8390.

ELECTRICAL AND ILLUMINATING ENGINEER, 41, married; 23 years' experience, wireman to superintendent, estimator and engineer, instructor in applied electrical engineering in technical school. Experienced wiring power stations, commercial and industrial buildings. Five years' engineering for architects, writing specifications and designing electrical installations for office buildings, hotels, hospitals, industrial buildings. C-8460.

GRADUATE ELECTRICAL ENGINEER, 30. Two years' railroad shop and power plant experience, 4¾ years' large eastern railroad electrical engineer's office, drafting and design, appraisal electrical and power plant machinery, investigation and reports of engineering projects. Nineteen months electrician, U. S. Shipping Board diesel and diesel-electric motorships. Speaks Spanish. C-8160.

ELECTRICAL ENGINEER, 32, married, B. S. Nine years with large public utility. Six years power station and substation design and layout, including purchase of equipment and materials. Three years cable inspector and tester. Three years' practical field experience. Four years' clerical and executive experience. Location, Metropolitan, New York. B-3698.

ELECTRICAL ENGINEER, married, 35. Several years with design, construction corporation on electrical design, construction, starting up, and specifications, covering large power plants, industrial electric drives and auxiliaries. Several years with large manufacturer of electrical equipment, designer, switching, control, general engineer. Experience writing reports and some in technical paper writing. B-3172.

ELECTRICAL DESIGNER, age 38, married. Fourteen years' public utility experience, five different corporations, power plant, switching station, substation, both indoor and outdoor. Desires connection with public utility or industrial organization. Available now. Location preferred, East. C-8490.

RECENT GRADUATE ELECTRICAL ENGINEER, married, age 24. Location, Northern United States. Available now. C-7975.

ELECTRICAL ENGINEER, graduate Georgia Technology 1930, cooperative plan. Worked alternate months, five years substation maintenance and office.

GRADUATE ELECTRICAL ENGINEER, American, 31, married; eight years' public utility experience, hydroelectric developments, high-tension switching stations and distribution substations complete engineering design and supervision of several major developments in the United States and in South America; seeks permanent connections. Speaks, German and Spanish. C-8470.

SALES ENGINEER, 33, married, Chilean Technical graduate, Westinghouse graduate students course. One year University of Pennsylvania; seven years of actual sales work in Mexico and Chile with Westinghouse. Speaks Spanish and English fluently. Desires location in utility or manufacturing company. Location, immaterial. Available immediately. C-8524.

GRADUATE, 1929 with B. S. in electrical engineering, 23, desires position with railway or public utility company. One year Westinghouse student course and has some diagram experience. Location, Middle West or Pacific Coast preferred. C-8523.

MECHANICAL-ELECTRICAL ENGINEER, with 15 years' experience in layout, construction and operation of industrial plants, seven years' design of power plants, five years' machine design, 2 years' machine shop practise, engineering college graduate. Desires position as engineer, chief draftsman or in similar capacity. Available immediately. B-2492.

GRADUATE ELECTRICAL ENGINEER, single, 31, solicits inquiries. Nine years' experience design of power stations, substations and industrial plants, also outdoor substations. Worked with Westinghouse in Pittsburgh and New York Edison Company. Speaks and writes German. Knowledge of French, Spanish. Will locate anywhere. Available immediately. First-class references. C-2522.

ENGINEER, ELECTRICAL, B. S.-E, E. Over 20 years' experience on power plants, substations and industrial plants. Ten years' experience on power plants, substations and industrial plants. Ten years' as designer and checker; ten years' as assistant electrical engineer, covering specifications, supervision of design, purchase of equipment, estimates, consultation, correspondence, etc. Available now. Will accept any reasonable offer. C-3785.

FIRST-CLASS TROUBLE SHOOTER wants work at once. Eight years in public utility and industrial plants. I. C. S. graduate in E. E. and associate A. I. E. E. C-8522.

RADIO ENGINEER, B. S. in E. E., 23, one year in general radio research laboratory. One year as design engineer with radio-receiver manufacturer. Desires position of similar character in laboratory of receiver manufacturer or allied electrical activity. C-8521.

TRANSMISSION AND DISTRIBUTION ENGINEER, desires position in tropical climate. Now superintendent of a tramway in City in Brazil. Experienced in transmission of Irish nationality, speaks Portuguese. Holds first-class diploma Foradoz House, Graduate I. E. E. C-8519.

ELECTRICAL ENGINEER, graduate Georgia Tech. 1930, cooperative plan. Worked alternate months, five years' substation maintenance and office engineering. Rebuilding transformers, switches, lightning arresters, work with electric furnaces, rectifiers, motors, etc. Checking and mapping distribution systems, work orders. Single, excellent physical condition. Desires position, preferably with public utilities. Location, immaterial. C-7847.

ELECTRICAL-MECHANICAL ENGINEER, executive; 23 years' diversified experience as an engineer and executive in industrial plant equipment and operation. Particularly successful in present connection along lines of mechanical plant improvement and in obtaining employee cooperation through personnel training. Can refer freely to each connection held. C-7839.

SUPERINTENDENT, married, 42; 20 years' experience in electrical construction of power plants, automatic railway substations and mercury arc rectifiers. Desires connection with public utility or large manufacturing company. Available because company discontinued construction. C-8520.

SUPERINTENDENT, general foreman or field engineer for construction company or utility, (electric, gas, or water) on construction, maintenance or operating. Young, energetic, ability and experience handling large crews and jobs of many details. Good organizer. B-9380.

ELECTRICAL ENGINEER, graduate Union College, 1924, age 28, married, good appearance, 15 months General Electric Test Course. Four years' public utility operation; 15 years' noncommercial radio experience. Location, East. Available at once. C-4182.

ELECTRICAL ENGINEER, B. S. degree, 33, Westinghouse sales course, 15 months sales assistant, three years technical advertising, four and one-half years development, sales, surveys on oil-electric locomotives. Executive ability. Desires sales position electric traction or industrial electrical equipment; or engineering with railroad electric-traction department. References. Location will consider. C-7545.

GRADUATE ENGINEER with strong theoretical background. Extensive practical experience in public relations, valuation, rate-making, special economic studies, investigations and research. Well qualified as a junior executive for large industrial or public utility corporation, or director of research special investigations or publicity. Now engaged as executive. Available on reasonable notice. C-6733.

GRADUATE ELECTRICAL ENGINEER, 34; power-house, railroad shop, steel-mill electric operation, repair and test experience; power-plant, substation, railroad electrification design; posted on economic and financial fundamentals and statistics; six languages. Valuable to management, financial, industrial organization. C-6952.

ELECTRICAL ENGINEER, 36, experienced in every phase of construction and maintenance (including South America), central stations, substations, inspections, tests, distribution systems, pole lines; one year operating. Desires position at home, or abroad, will represent manufacturer in Brazil; elsewhere considered. Languages, English, French, Portuguese, working knowledge Spanish, German, Italian. Best references. Available immediately. C-2021.

ADVERTISING-ELECTRICAL ENGINEER, 38, extensive and varied career, chiefly in executive capacities. Author of technical articles. Desires opportunity in advertising with either agency, publishing house or sales counsel. Initial salary secondary, where engineering background, wide acquaintanceship, originality, ability to analyze, and proper personality, may be capitalized. B-9079.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, single, 24. Desires position along lines of design, development, or experimental work in industrial, railway electrification, or utility fields. Two years' General Electric test. Available now. Location, East or Middle West. C-4583.

ENGINEER, E. E. degree, age 30, married. Wide experience in layout, design and research of small electrical parts, radio, motion picture and sound system apparatus. Desires position in laboratory or drafting room. A-1 references. Available immediately. Location, New York. B-5138.

ELECTRICAL ENGINEER, 32, married. Nine years' general testing and development experience including railway equipment, with exceptional practical knowledge of power mercury arc rectifiers. Desires position in test or operating departments, of public utility or electric railroad, South, East or Chicago. C-7875.

ELECTRICAL ENGINEER, 36, single, European education, North American training, good executive, 9 languages. Eight years' experience construction, maintenance, operation large public utility plants. Seven years sales, various branches. Expert in exports and government supplies. Traveled over the world. Adaptable to any country, climate. Available now. Desires position abroad. C-8351.

ELECTRICAL ENGINEER, 24, married. Desires engineering work. Has had experience with oscillographs and radio. Holds second grade commercial wireless operators license. Has public utility test experience. Also surveying experience. Personal interview desired. C-3035.

SALES AND EXECUTIVE ENGINEER, trained at Worcester Polytechnic Institute. Six years' sales experience; straight sales engineering, jobbing sales, sales promotion and management. Has contacted with electrical and mechanical companies. Traveled East, Middle West, South. Well acquainted with New England. C-5431.

GRADUATE ELECTRICAL ENGINEER, 26, one year's experience large public utility, power engineer, 1½ years research department large manufacturing company. Experienced, design of electromagnetic appliances, mechanical design and equipment layouts. Drafting experience. Best references. Ability to handle men. Desires connection, public utility, motor or industrial control manufacturing. Available two weeks' notice. C-7737.

ELECTRICAL-MECHANICAL ENGINEER with extensive and mature experience in the United States and foreign fields would like a connection where his knowledge and experience would be of most benefit, design, specifications, estimates construction, superintendence of operation power and industrial plants, engineering correspondence, engineering sales—whatever you need. C-408.

GRADUATE ELECTRICAL ENGINEER, age 29, married. Five years' practical experience construction and maintenance work. C-8539.

SUPERINTENDENT of distribution, 43, married. Electrical and industrial management. Twenty years' electric utility operating experience, in engineering, construction, operation, maintenance of distributing and transmission lines, substations, first aid and educational work. Has sufficient public utility operating experience to qualify for position of superintendent. Demonstrated record of executive ability. C-8411.

ELECTRICAL ENGINEER, graduate, E. E. degree, 28, married. Three years' experience, relays, relay studies large electric power and light utility, operating New York City. Three years' testing, design and development work on new electrical appliances and materials Experience includes considerable outside contact leading electrical manufacturers. Available immediately. Location, New York City. B-8793.

Membership

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before January 31, 1931.

Adams, E. C., Pacific Tel. & Tel. Co., Portland, Ore.
Allen, C. S., General Electric Co., Schenectady, N. Y.
Altstadt, A. O., T. M. E. R. & L. Co., Milwaukee, Wis.
Anderson, W. A., United Electric Lt. & Pr. Co., New York, N. Y.
Aranda, F. T., J. F. Azcarate S. en C., Mexico City, Mex.
Arzadon, F. S., 27 W. Superior St., Chicago, Ill.
Atkinson, F. W., General Electric Co., Schenectady, N. Y.
Atlee, Z., General Electric Co., Schenectady, N. Y.
Baily, L. W., General Electric Co., Philadelphia, Pa.
Baker, R. A., Public Service Elec. & Gas Co. of N. J., Hackensack, N. J.
Barrett, W. J., (Member), N. J. Bell Tel. Co., Newark, N. J.
Bazley, W. J., Jr., Southern New England Tel. Co., Stamford, Conn.
Beeman, D. L., General Electric Co., Philadelphia, Pa.
Belknap, M. M., Iowa Railway & Light Corp., Perry, Ia.
Berry, W. J., General Electric Co., Erie, Pa.
Bishop, S. J., American Tel. & Tel. Co., Hartford, Conn.
Bogdanowski, J. W., Brooklyn Edison Co., Brooklyn, N. Y.
Booth, D. M., Cia. Hydroelectrica Guanajuatense, S. A., Mexico City, Mex.
Borden, A. O., Portland General Electric Co., Portland, Ore.
Boyd, G. G., Public Service Co. of No. Ill., Evanston, Ill.
Bradford, H. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Bramhall, F. B., Western Union Telegraph Co., New York, N. Y.
Brant, T. J., Box 427, Whitby, Ont., Can.
Brazil, C., West Coast Power Co., Shelton, Wash.
Brotz, A. J., Howell Electric Motors Co., Howell, Mich.
Browne, H. L., (Member), Western Union Telegraph Co., New York, N. Y.
Browning, G. H., (Member), Doble Engineering Co.; National Co., Winchester, Mass.
Brune, O., Mass. Inst. of Technology, Cambridge, Mass.
Bugg, V. M., (Member), General Research Corp., New York, N. Y.
Burn, E. M., General Electric Co., Bridgeport, Conn.
Burner, G. I., Pennsylvania Railroad, Philadelphia, Pa.
Byrne, J. J., General Electric Co., Lynn, Mass.
Cameron, H. J., General Electric Co., Fort Wayne, Ind.
Cassidy, E. C., Reading Railroad Co., Philadelphia, Pa.
Cerow, J. A., Jr., Brooklyn Edison Co., Brooklyn, N. Y.
Churchman, A. C., General Electric Co., Fort Wayne, Ind.
Cobb, W. O., Public Service Co. of Okla., Tulsa, Okla.
Cockrell, E. A., T. M. E. R. & L. Co., Milwaukee, Wis.
Collins, A. K., F. W. Glassol Co., New York, N. Y.
Connor, W. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Coulter, C. C., General Electric Co., Schenectady, N. Y.
Coursey, R. W., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Cowles, L. G., Bell Tel. Laboratories, New York, N. Y.
Crampton, R. E., Central Public Service Co., Houghton, Mich.
Crawford, D. M., Brooklyn Edison Co., Brooklyn, N. Y.
Crawford, J. M., Shawinigan Water & Power Co., Montreal, Que., Can.
Croswell, R. A., Radio Service, Farmington Falls, Me.
Daiger, G. P., Johns Hopkins University, Baltimore, Md.
Dannacher, C. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Darling, G., Vancouver Technical School, Vancouver, B. C., Can.
Dasha, L. B., New York Central Railroad Co., New York, N. Y.
Davidson, R., Big Four Railway, Indianapolis, Ind.
Davis, F. A., (Member), Telephone, Bond & Share Co., Kansas City, Mo.
deMars, P. A., (Fellow), Tufts College, Boston, Mass.
Demas, G. N., Western Union Telegraph Co., New York, N. Y.
Deming, P. S., Oklahoma Gas & Electric Co., Seminole, Okla.
Denton, S. M., U. S. Bureau of Reclamation, Denver, Colo.
Detwiler, F. T., Stevens Inst. of Technology, Hoboken, N. J.
D yoe, G. M., Jr., Bell Telephone Laboratories, New York, N. Y.
Diaz G., E., Empresa Telef. Ericsson, Mexico City, Mex.
Donatic, E. F., Republic Steel Corp., Chicago, Ill.
Dowell, M. F., General Electric Co., Bridgeport, Conn.

Duke, A. M., Union Electric Lt. & Pr. Co., St. Louis, Mo.

Ebbler, F. W., Union Electric Lt. & Pr. Co., St. Louis, Mo.

Eberhard, J. J., General Electric Co., Schenectady, N. Y.

Edmunds, W. M., University of Arizona, Tucson, Ariz.

Ehrmeyer, W. J., Commonwealth Edison Co., Chicago, Ill.

Ellenberger, W. J., United States Bureau of Standards, Washington, D. C.

Ellis, H. E., Westinghouse Elec. & Mfg. Co., East Springfield, Mass.

Endicott, W., General Electric Co., Minneapolis, Minn.

Eppley, M., (Member), Eppley Laboratory, Inc., Newport, R. I.

Fesperman, H. D., Tallassee Power Co., Badin, No. Car.

Ficken, R. J., Engineering School of Milwaukee, Milwaukee, Wis.

Fisher, S., Allis-Chalmers Mfg. Co., West Allis, Wis.

Flynn, A. T., General Electric Co., Bridgeport. Conn.

Forsyth, H. D., Appalachian Electric Power Co., Lynchburg, Va.

Framme, R. J., Bell Tel. Laboratories, New York, N. Y.

Frankenfield, M. W., General Electric Co., Philadelphia, Pa.

Fredendall, B., National Broadcasting Co., New York, N. Y.

Fretz, O. G., Southwestern Bell Tel. Co., Oklahoma City, Okla.

Fruhner, E. T., American Tel. & Tel. Co., New York, N. Y.

Fuller, L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Gallup, R. K., R. C. A. Communications, Inc., Rocky Point, N. Y.

Gardner, J. B., Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio

Gehrke, J. W., Dayton Pr. & Lt. Co.; Union Gas & Elec. Co., Dayton, Ohio

Gilbert, D. C., New Jersey Bell Tel. Co., Newark, N. J.

Gill, R. L., Public Service Co. of No. Ill., Waukegan, Ill.

Goulding, H., New York Edison Co., New York, N. Y.

Gowans, F. D., General Electric Co., Erie, Pa.

Graf, J. J., (Member), D. L. & W. R. R., Scranton, Pa.

Granbois, K. J., Penna. Water & Power Co., Holtwood, Pa.

Gray, A. W., R. C. A. Communications, Inc., Bolinas, Calif.

Greenwood, J., 507 West St., New York, N. Y.

Grueter, F. J., National Electric Light Association, New York, N. Y.

Gunther, E. T., General Cable Corp., Dallas, Tex.

Hall, G. O., General Electric Co., Schenectady, N. Y.

Hamilton, R. W., Dominion Electric Protection Co., Montreal, Que., Can.

Hammett, C. E., University of Nebraska, Lincoln, Nebr.

Hammond, H. K., Metropolitan Edison Co., Reading, Pa.

Handley, W. H., United Engineers & Constructors, Inc., Philadelphia, Pa.

Hango, J. R., Duke-Price Power Co., Isle Maligne, Que., Can.

Hanson, D. H., General Electric Co., Fort Wayne, Ind.

Hayes, V. J., Conn. Light & Power Co., Waterbury, Conn.

Hays, D., (Member), General Electric Co., Bridgeport, Conn.

Hearson, L. T., American Tel. & Tel. Co., Chicago, Ill.

Hickey, J. P., Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio

Hill, L. W., (Member), Southern Bell Tel. & Tel. Co., Atlanta, Ga.

Hillis, H. F., Worcester Polytechnic Institute, Worcester, Mass.

Hinz, H., D. L. & W. R. R., Hoboken, N. J.

Hively, M. W., General Electric Co., Pittsfield, Mass.

Hoffman, H., (Member), Erikson Electric Co., New York, N. Y.

Holdaway, V. L., Bell Telephone Laboratories, New York, N. Y.

Hoop, J. G., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Hornberger, F. W., Commonwealth Edison Co., Chicago, Ill.

Howells, T., Jr., General Electric Co., Schenectady, N. Y.

Huggins, A. H., Weirton Steel Co., Weirton, W. Va.

Hutchins, B. M., Penna. Power & Light Co., Allentown, Pa.

Hyatt, W. R., Hydro Electric Power Comm. of Ontario, Toronto, Ont., Can.

Ingram, A. G., Illinois Steel Co., South Chicago, Ill.

Irvine, T. F., (Member), Indiana Bell Tel. Co., Indianapolis, Ind

Jaffe, J. J., 118 Providence St., Worcester, Mass.

Johnson, B. W., Western Union Tel. Co., New York, N. Y.

Jones, V. B., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Karageorges, G. P., 1037 Berwyn Ave., Chicago, Ill.

Khanna, M. L., Engineering School of Milwaukee, Milwaukee, Wis.

Koerner, E. A., General Motors Radio Corp., Dayton, Ohio

Larson, L. M., U. S Navy, U. S S. Lexington, San Pedro, Calif.

Lawaetz, F. O., F. L. Smith & Co., New York, N. Y.

Laws, H. S., General Electric Co., Schenectady, N. Y.

Leach, J. L., National Electric Light Association, New York, N. Y.

Lear, C. M., General Electric Co., Schenectady, N. Y.

Levinton, H. L., Mass. Inst. of Technology, Cambridge, Mass.

Lott, E. J., New Jersey Bell Tel. Co., East Orange, N. J.

Loucks, I. H., Baird Hardware Co., Gainesville, Fla.

MacGregor, J. G., Canadian Utilities, Ltd., Calgary, Alberta, Can.

Malkin, A., Ross & MacDonald, Inc., Montreal, Que., Can.

Manning, E. W., General Electric Co., Schenectady, N. Y.

Marr, J. S., Michigan Alkali Co., Wyandotte, Mich.

Maseng, T., Byllesby Engg. & Mgt. Corp., Chicago, Ill.

Massenburg, W. B., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Mattson, W. W., Hartford Steam Boiler Inspection & Insurance Co., Hartford, Conn.

Maurer, G. P., The Falk Corp., Milwaukee, Wis.

Maxwell, A. F., Lake Erie Pr. & Lt. Co., Fremont, Ohio

Maynard, N. A., Associated Gas & Electric System, Cambridge, Mass.

McCammon, J. W., (Member), Beauharnois Power Corp., Montreal, Que., Can.

McDonald, C. J., Western Electric Co., Chicago, Ill.

McKinney, J. H., (Member), Dept. of Commerce, Dallas, Tex.

Mellrud, H. E., Commonwealth Edison Co., Chicago, Ill.

Menendez, R. A., Milwaukee Electric Ry. & Lt. Co., Milwaukee, Wis.

Metcalfe, D., American Tel. & Tel. Co., New York, N. Y.

Metz, H. E., Landers, Frary & Clark, New Britain, Conn.

Mier, F. O., J. F. Azcarate S. en C., Mexico City, Mex.

Miles, L. F., Station WHP, Harrisburg, Pa.

Miller, E. H., Kansas Gas & Electric Co., Wichita, Kans.

Millmann, E. H., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Mitchell, O. V., U. S. Patent Office, Washington, D C.

Morningstern, W. B., Western Electric Co., Kearny, N. J.

Mowry, K. W., Allied Engineers, Inc., Grand Rapids, Mich.

Mueller, R., Bell Telephone Laboratories, New York, N. Y.

Murray, W. K., General Electric Co., Schenectady, N. Y.

Newman, A. F., Ford Motor Co., Dearborn, Mich.

Nordling, H. G., Alaska Juneau Gold Mining Co., Juneau, Alaska

Norris, C. B., Tulane University, New Orleans, La.

Orrell, H., Diehl Mfg. Co., Elizabethport, N. J.

Overstreet, J. S., General Electric Co., Schenectady, N. Y.

Parker, W. H., Jr., Mass. Inst. of Technology, Cambridge, Mass.

Parrott, W. G., Jr., Tennessee Electric Power Co., Chattanooga, Tenn.

Peterson, E. L., (Member), American Gas & Electric Co., New York, N. Y.

Pfeiff, C. A., Warner Bros., Studios, Brooklyn, N. Y.

Pickslay, W. M., Jr., Allis-Chalmers Mfg. Co., West Allis, Wis.

Porter, L. F., New York Edison Co., New York, N. Y.

Protzman, R. E., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.

Quirino, F., Allen-Bradley Co., Milwaukee, Wis.

Ratzman, H. A., Wisconsin Telephone Co., Milwaukee, Wis.

Record, L. E., General Electric Co., Schenectady, N. Y.

Reed, J. F., Jr., Bell Tel. Co. of Pa., Pittsburgh, Pa.

Reeves, W. O., Atlantic Refining Co., Philadelphia, Pa.

Richards, W. N., N. Snellenburg & Co., Philadelphia, Pa.

Rippere, R. O., Bell Telephone Laboratories, New York, N. Y.

Robert, L. W., Jr., Robert & Co., Inc., Atlanta, Ga.

Roberts, W. P., Monongahela West Penn Public Service Co., Fairmont, W. Va.

Robinson, L. L., Worcester Polytechnic Institute, Worcester, Mass.

Roede, C. B., Sperry Products, Inc., Brooklyn, N. Y.

Rosti, A., Route 3, Kellerton, Ia.

Roth, C. W., Roth Bros. & Co., Chicago, Ill.

Roush, C. G., Westinghouse Elec. & Mfg. Co., Kansas City, Mo.

Rummel, G. A., Jr., Chicago Surface Lines, Chicago, Ill.

Russell, A. W., Buckeye Cotton Oil Co., Memphis, Tenn.

Russell, W. F., Hall & Connolly, Inc., New York, N. Y.

Sailer, L. R., Columbia University, New York, N. Y.

Saylor, E. R., General Electric Co., Schenectady, N. Y.

Scheuerman, E. W., Pillar Electric Co., Chicago, Ill.

Schmidt, P. C., New York Edison Co., New York, N. Y.

Scoville, M. E., General Electric Co., Schenectady, N. Y.

Shafer, A. J., Wisconsin Pr. & Lt. Co., Madison, Wis.

Shaw, J., 304 Denton Ave., Lynbrook, N. Y.

Shaw, W. H., Houston Lighting & Power Co., Houston, Tex.

Skipper, E. M., Lock Insulator Corp., Baltimore, Md.

Smith, D. E., Oklahoma Gas & Electric Co., Bristow, Okla.

Somers, F. J., Bell Telephone Laboratories, Inc., New York, N. Y.

Sowers, L. K., General Electric Co., Schenectady, N. Y.

Stay, C. A., United Electric Lt. & Pr. Co., New York, N. Y.

Stiles, M. R., Bell Telephone Laboratories, New York, N. Y.

Stoddard, H. E., Thomson Gibb Elec. Welding Co., Lynn, Mass.

Stoker, J., 156 N. Grant St., Lafayette, Ind.

Stoody, R. E., Cline Electric Mfg. Co., Chicago, Ill.

Sullivan, T. H., Ruggles-Klingemann Mfg. Co., Salem, Mass.

Sweet, A. L., General Electric Co., Schenectady, N. Y.

Swerdlow, N., General Electric Co., Philadelphia, Pa.

Taylor, R. S., Philadelphia Electric Co., Philadelphia, Pa.

Teker, J. W., General Electric Co., Erie, Pa.

Teuscher, F. P., Hydroelectrica Guanajuatense S. A., Mexico, D. F., Mex.

Theophilus, R. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Thompson, H. M., Hollis French & Allen Hubbard, Engrs., Boston, Mass.

Thompson, P. S., General Cable Corp., Fort Wayne, Ind.

Torgersen, H., New York University, New York, N. Y.

Valier, C. E., Jr., Southwestern Bell Tel. Co., St. Louis, Mo.

Varsdal, V. K., Western Electric Co., Inc., Kearny, N. J.

Vaughan, C. F., General Electric Co., Pittsfield, Mass.

Viola, A. G., Wagner Electric Corp., St. Louis, Mo.

Wall, C. T., The Northwestern Bell Tel. Co., Minneapolis, Minn.

Watson, H. E., Columbia Engg. & Mgt. Corp., Cincinnati, Ohio

Way, D. M., General Electric Co., Schenectady, N. Y.

Webb, C. C., Armstrong Cork Co., Lancaster, Pa.

Weigle, R. M., General Electric Co., Erie, Pa.

Wheeler, L. B., Western Union Telegraph Co., New York, N. Y.

Wilkins, W. G., Key Boiler Equipment Co., East St. Louis, Ill.

Willoch, H., Alan Wood Steel Co., Conshohocken, Pa.

Wilson, T. A., General Electric Co., Pittsfield, Mass.

Winckler, R. H., Public Service Elec. & Gas Co., Roseland, N. J.

Wisbon, C. B., Lake Erie Pr. & Lt. Co., Fremont, Ohio

Wortman, W. J., General Electric Co., Schenectady, N. Y.

Wright, O. C., St. Louis Public Service Co., St. Louis, Mo.
(Applicant for re-election)

Wurzbach, H. A., American Tel. & Tel. Co., Denver, Colo.

Total 234

Foreign

Federici, M. E., International Tel. & Tel. Lab., Inc., London, Eng.

Gillon, E. G., University of Louvain, Louvain, Belgium

Hayward, G. B., Ebro Irrigation & Power Co., Lerida, Spain

Kahale, N., Tramways & Electricite de Damas, Damascus, Syria

Miridjanian, N. M., Columbia Graphophone Co., Istanbul, Turkey

Nakashidze, D. M., (Prince), Ford Motor Co. Exp., Inc., Istanbul, Turkey

Roy, B. B., Ahmedabad Electricity Co., Ltd., Ahmedabad, India

Total 7

Personnel

Institute Officers 1930-1931

President

(Term expires July 31, 1931)
WILLIAM S. LEE

Junior Past Presidents

(Term expires July 31, 1931)
R. F. SCHUCHARDT

(Term expires July 31, 1932)
HAROLD B. SMITH

Vice-Presidents

(Terms expire July 31, 1931)
HERBERT S. EVANS (District No. 6)
W. S. RODMAN (District No. 4)
C. E. FLEAGER (District No. 8)
E. C. STONE (District No. 2)
C. E. SISSON (District No. 10)

(Terms expire July 31, 1932)
H. V. CARPENTER (District No. 9)
G. C. SHAAD (District No. 7)
I. E. MOULTROP (District No. 1)
H. P. CHARLESWORTH (District No. 3)
T. N. LACY (District No. 5)

Directors

(Terms expire July 31, 1931)
F. C. HANKER
E. B. MEYER
H. P. LIVERSIDGE

(Terms expire July 31, 1932)
J. ALLEN JOHNSON
A. M. MacCUTCHEON
A. E. BETTIS

(Terms expire July 31, 1933)
J. E. KEARNS
F. W. PEEK, JR.
C. E. STEPHENS

(Terms expire July 31, 1934)
A. B. COOPER
A. E. KNOWLTON
R. H. TAPSCOTT

National Treasurer

(Term expires July 31, 1931)
W. I. SLICHTER

National Secretary

(Term expires July 31, 1931)
F. L. HUTCHINSON

General Counsel

PARKER & AARON
30 Broad Street, New York, N. Y.

Local Honorary Secretaries

T. J. Fleming, Calle B. Mitre 519, Buenos Aires, Argentina, S. A.

H. W. Flashman, Aus. Westinghouse Elec. Co., Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.

Frederick M. Servos, Rio de Janeiro Tramways Lt. & Pr. Co., Rio de Janeiro, Brazil, S. A.

A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.

A. S. Garfield, 173 Boulevard Haussmann, Paris (8e), France.

Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.

P. H. Powell, Canterbury College, Christchurch, New Zealand.

M. Chatelain, Lesnoi Polytechnic Institute, Apt. 27, Leningrad, U. S. S. R.

Axel F. Enstrom, Ingeniorsvetenskapsakademien, Stockholm, Sweden.

W. Elsdon-Dew, P. O. Box 4563, Johannesburg, Transvaal, Africa.

GENERAL COMMITTEES

Executive Committee

W. S. Lee, Chairman, 535 Fifth Avenue, New York, N. Y.
J. Allen Johnson, W. I. Slichter,
A. M. MacCutcheon, Harold B. Smith,
I. E. Moultrop, C. E. Stephens.

Finance Committee

C. E. Stephens, Chairman, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
H. P. Charlesworth, E. B. Meyer.

Meetings and Papers Committee

A. E. Knowlton, Chairman, *Electrical World*, 10th Ave. & 36th St., New York, N. Y.
C. S. Rich, Secretary, 33 W. 39th St., New York, N. Y.
V. Bush, W. H. Harrison,
W. S. Gorsuch, C. E. Skinner,
T. A. Worcester.

Chairman of Committee on Coordination of Institute Activities, *ex-officio*.
Chairmen of Technical Committees, *ex-officio*.

Publication Committee

W. S. Gorsuch, Chairman, 600 W. 59th St., New York, N. Y.
H. P. Charlesworth, A. E. Knowlton,
F. L. Hutchinson, E. B. Meyer.

Committee on Coordination of Institute Activities

H. P. Charlesworth, Chairman, 463 West St., New York, N. Y.
W. S. Gorsuch, Everett S. Lee,
F. L. Hutchinson, E. B. Meyer,
A. E. Knowlton, C. E. Stephens.

Board of Examiners

H. W. Drake, Chairman, Western Union Telegraph Co., 60 Hudson St., New York, N. Y.
H. A. Currie, R. H. Marriott,
H. Goodwin, Jr. L. W. W. Morrow,
S. P. Grace, A. L. Powell,
A. H. Kehoe, W. R. Smith,
H. A. Kidder, S. D. Sprong,
R. H. Tapscott.

Sections Committee

Everett S. Lee, Chairman, General Electric Co., Schenectady, N. Y.

W. B. Kouwenhoven,
W. S. Rodman,
I. M. Stein,
W. H. Timbie

Chairmen of Sections, *ex-officio.*

Committee on Student Branches

W. H. Timbie, Chairman, Massachusetts Institute of Technology, Cambridge, Mass.

Herbert S. Evans,
F. O. McMillan,
Charles F. Scott,
W. J. Seeley.

Student Branch Counselors, *ex-officio.*

Membership Committee

J. Allen Johnson, Chairman, Room 302, Electric Building, Buffalo, N. Y.

Vice-Chairmen

E. P. Coles,
D. I. Cone,
Herbert B. Dwight,
E. F. Gehrkens,
James Harrison,
C. R. Jones,
R. L. Kirk,
T. G. LeClair,
D. W. Proebstel,
E. M. Wood.

Ex-officio

Chairmen of Section Membership Committees.

Headquarters Committee

R. H. Tapscott, Chairman, 124 E. 15th St., New York, N. Y.

F. L. Hutchinson,
C. E. Stephens.

Law Committee

E. B. Meyer, Chairman, 70 Park Place, Newark, N. J.

C. O. Bickelhaupt,
H. A. Kidder,
L. F. Morehouse,
W. I. Slichter.

Public Policy Committee

Bancroft Gherardi, Chairman, 195 Broadway New York, N. Y.

C. C. Chesney,
F. B. Jewett,
Farley Osgood,
Harris J. Ryan,
R. F. Schuchardt,
Harold B. Smith.

Standards Committee

F. D. Newbury, Chairman, Westinghouse E. & M. Co., East Pittsburgh, Pa.

C. M. Gilt,
C. R. Harte,
A. M. MacCutcheon,
J. F. Meyer,
V. M. Montsinger,
L. T. Robinson,
C. E. Skinner,
W. I. Slichter.

Ex-officio

Chairmen of Working Committees.

Chairmen of A. I. E. E. delegations on other standardizing bodies.

President of U.S. National Committee of I. E. C.

Edison Medal Committee

Appointed by the President for term of five years.

(Terms expire July 31, 1931)
John W. Howell,
L. F. Morehouse,
David B. Rushmore.

(Terms expire July 31, 1932)
H. P. Charlesworth,
Paul M. Lincoln,
C. E. Skinner.

(Terms expire July 31, 1933)
D. C. Jackson, Chairman.
C. F. Harding,
F. A. Scheffler.

(Terms expire July 31, 1934)
L. W. W. Morrow,
W. S. Rugg,
R. F. Schuchardt.

(Terms expire July 31, 1935)
C. I. Burkholder,
F. A. Gaby,
Harris J. Ryan.

Elected by the Board of Directors from its own membership for term of two years.

(Terms expire July 31, 1931)
J. Allen Johnson,
E. B. Meyer,
A. M. MacCutcheon.

(Terms expire July 31, 1932)
A. E. Knowlton,
Harold B. Smith,
R. H. Tapscott.

Ex-officio

William S. Lee, President,
W. I. Slichter, National Treasurer.
F. L. Hutchinson, National Secretary.

Lamme Medal Committee

(Terms expire July 31, 1931)
Charles F. Scott, Chairman.
H. H. Barnes, Jr.,
N. W. Storer.

(Terms expire July 31, 1932)
H. P. Charlesworth,
C. C. Chesney,
R. B. Williamson.

(Terms expire July 31, 1933)
Ralph D. Mershon,
Julian C. Smith,
Percy H. Thomas.

Committee on Code of Principles of Professional Conduct

Frank B. Jewett, Chairman, 195 Broadway, New York, N. Y.

A. H. Babcock,
G. Faccioli,
Harris J. Ryan,
R. F. Schuchardt,
C. E. Stephens,
John B. Whitehead.

Committee on Award of Institute Prizes

A. E. Knowlton, Chairman, *Electrical World*, 10th Ave. & 36th St., New York, N. Y.

L. W. Chubb,
W. S. Gorsuch.

Committee on Safety Codes

A. W. Berresford, Chairman, 420 Lexington Ave., New York, N. Y.

F. V. Magalhaes, Vice-Chairman.

A. E. Bettis,
J. C. Forsyth,
H. B. Gear,
F. D. Knight,
M. G. Lloyd,
Wills Maclachlan,
R. W. E. Moore,
John D. Noyes,
F. A. Pattison,
H. R. Sargent,
H. R. Searing,
H. S. Warren.

Committee on Columbia University Scholarships

W. I. Slichter, Chairman, Columbia University, New York, N. Y.

Francis Blossom,
H. C. Carpenter.

Committee on the Engineering Profession

H. A. Kidder, Chairman, 600 W. 59th St., New York, N. Y.

J. P. Alexander,
T. F. Barton,
B. M. Brigman,
H. P. Charlesworth,
L. F. Leurey,
L. W. W. Morrow,
John C. Parker,
John R. Price,
Herbert S. Sands,
M. R. Scharff,
H. H. Schoolfield,
W. I. Slichter,
J. B. Thomas.

Advisory Committee to the Museums of the Peaceful Arts

J. P. Jackson, Chairman, N. Y. Edison Co., 130 E. 15th St., New York, N. Y.

C. O. Bickelhaupt,
Randolph H. Nexsen.

Committee on Popular Science Award

A. E. Knowlton, Chairman, *Electrical World*, 10th Ave. & 36th St., New York, N. Y.

H. P. Charlesworth,
C. E. Stephens.

TECHNICAL COMMITTEES

Automatic Stations

F. Zogbaum, Chairman, N. Y. Edison Co., 4 Irving Place, New York, N. Y.

Chester Lichtenberg, Secretary, General Electric Co., 6901 Elmwood Ave., Philadelphia, Pa.

F. F. Ambuhl,
L. D. Bale,
C. W. Colvin,
A. M. Garrett,
Joseph Hellenthal,
C. A. Mayo,
I. E. Moultrop,
M. E. Reagan,
O. J. Rotty,
Garland Stamper,
D. W. Taylor,
L. J. Turley.

Communication

G. A. Kositzky, Chairman, Ohio Bell Telephone Co., 750 Huron Road, Cleveland, Ohio.

H. S. Osborne, Vice-Chairman.

H. M. Bascom,
G. R. Benjamin,
B. K. Boyce,
A. F. Brooks,
W. H. Capen,
J. L. Clarke,
R. N. Conwell,
B. R. Cummings,
H. W. Drake,
R. D. Evans,
C. E. Fleager,
D. H. Gage,
S. P. Grace,
Erich Hausmann,
H. L. Huber,
C. F. King, Jr.,
R. H. Manson,
John Mills,
J. W. Milnor,
J. L. Niesse,
F. A. Raymond,
H. A. Shepard,
H. S. Sheppard,
A. N. Symes,
H. M. Turner,
F. A. Wolff.

Education

W. R. Work, Chairman, Carnegie Institute of Technology, Pittsburgh, Pa.

M. W. Alexander,
E. W. Allen,
J. W. Barker,
Edward Bennett,
P. S. Biegler,
H. W. Buck,
R. F. Chamberlain,
C. R. Dooley,
H. E. Dyche,
O. J. Ferguson,
H. H. Henline,
E. A. Loew,
A. H. Lovell,
H. S. Osborne,
H. W. Price,
W. S. Rugg,
W. T. Ryan,
R. F. Schuchardt,
G. B. Thomas,
W. H. Timbie,
W. E. Wickenden.

Electrical Machinery

Philip L. Alger, Chairman, General Electric Co., Schenectady, N. Y.

E. B. Paxton, Secretary, General Electric Co., Schenectady, N. Y.

L. F. Adams,
B. L. Barns,
W. M. Dann,
H. B. Dwight,
C. M. Gilt,
T. T. Hambleton,
A. L. Harding,
C. F. Harding,
S. L. Henderson,
L. F. Hickernell,
J. Allen Johnson,
H. C. Louis,
A. M. MacCutcheon,
O. K. Marti,
V. M. Montsinger,
E. L. Moreland,
F. D. Newbury,
R. W. Owens,
A. M. Rossman,
R. B. Williamson,
H. L. Zabriskie.

Electrochemistry and Electrometallurgy

P. H. Brace, Chairman, Westinghouse E. & M. Co., East Pittsburgh, Pa.

Lawrence Addicks,
T. C. Atchison,
Farley G. Clark,
S. K. Colby,
J. C. Hale,
F. C. Hanker,
W. E. Holland.
F. A. Lidbury,
R. G. Mansfield,
J. A. Seede,
C. E. Sisson,
H. Speight,
Magnus Unger,
G. W. Vinal,
J. B. Whitehead,
E. A. Williford,
J. L. Woodbridge,
C. D. Woodward.

Electric Welding

P. P. Alexander, Chairman, General Electric Co., River Works, West Lynn, Mass.

C. A. Adams,
A. M. Candy,
Alexander Churchward,
S. Dushman,
F. M. Farmer,
H. M. Hobart,
C. J. Holslag,
J. E. Kearns,
J. C. Lincoln,
Ernest Lunn,
B. T. Mottinger,
J. W. Owens,
J. Slepian,
William Spraragen.

Electrophysics

O. E. Buckley, Chairman, 463 West Street, New York, N. Y.

W. S. Gorton, Secretary, 463 West Street, New York, N. Y.

V. Bush,
W. G. Cady,
W. F. Davidson,
C. L. Fortescue,
W. B. Kouwenhoven,
G. M. J. Mackay,
K. B. McEachron,
L. W. McKeehan,
H. Nyquist,
W. S. Rodman,
J. Slepian.

Liaison Representatives of American Physical Society:

Professor Leigh Page,
Dr. W. F. G. Swann.

General Power Applications

C. W. Drake, Chairman, Westinghouse E. & M. Co., East Pittsburgh, Pa.

E. A. Armstrong,
James Clark, Jr.
J. F. Gaskill,
Clyde D. Gray,
John Grotzinger,
Fraser Jeffrey,
A. M. MacCutcheon,
H. A. Maxfield,
John Morse,
N. L. Mortensen,
A. M. Perry,
D. M. Petty,
F. O. Prior,
H. W. Rogers,
L. D. Rowell,
M. R. Woodward.

Instruments and Measurements

E. J. Rutan, Chairman, New York Edison Co., 92 Vandam St., New York, N. Y.

R. T. Pierce, Secretary, Weston Elec. Instrument Corp., 578 Frelinghuysen Ave., Newark, N. J.

H. S. Baker,
P. A. Borden,
H. B. Brooks,
O. J. Bushnell,
A. L. Cook,
E. D. Doyle,
Melville Eastham,
R. C. Fryer,
J. B. Gibbs
W. N. Goodwin, Jr.,
I. F. Kinnard,
O. A. Knopp,
A. E. Knowlton,
H. C. Koenig,
W. B. Kouwenhoven,
F. A. Laws,
E. S. Lee,
Paul MacGahan,
W. J. Shackelton.

Applications to Iron and Steel Production

A. C. Cummins, Chairman, Carnegie Steel Co., Duquesne, Pa.

F. B. Crosby,
M. M. Fowler,
S. L. Henderson,
A. M. MacCutcheon,
A. G. Pierce,
F. O. Schnure,
W. B. Shirk,
G. E. Stoltz,
Wilfred Sykes,
T. S. Towle,
H. A. Winne.

Production and Application of Light

George S. Merrill, Chairman, Nela Park, Cleveland, Ohio.

J. W. Barker,
A. E. Bettis,
W. T. Blackwell,
H. S. Broadbent,
J. M. Bryant,
W. T. Dempsey,
E. E. Dorting,
L. A. Hawkins,
H. H. Higbie,
W. C. Kalb,
C. L. Kinsloe,
R. D. Mailey,
P. S. Millar,
C. J. Stahl,
G. H. Stickney.

Applications to Marine Work

R. A. Beekman, Chairman, General Electric Co., Schenectady, N. Y.

H. F. Harvey, Vice-Chairman.

J. Y. Wilson, Secretary, American Bureau of Shipping, 24 Old Slip, New York, N. Y.

Edgar C. Alger,
H. C. Coleman,
E. M. Glasgow,
C. J. Henschel,
Wm. Hetherington, Jr.,
H. L. Hibbard,
J. E. Kearns,
A. Kennedy, Jr.,
J. B. Lunsford,
I. H. Osborn,
G. A. Pierce,
W. H. Reed,
Edgar P. Slack,
H. M. Southgate,
W. E. Thau,
A. E. Waller,
Oscar A. Wilde,
R. L. Witham,
W. N. Zippler.

Applications to Mining Work

Carl Lee, Chairman, 20 North Wacker Drive, Chicago, Ill.

A. R. Anderson,
Graham Bright,
John H. Edwards,
Frank E. Fisher,
E. J. Gealy,
L. C. Ilsley,
J. E. Kearns,
W. H. Lesser,
D. E. Renshaw,
W. F. Schwedes,
F. L. Stone,
B. F. Tillson,
J. F. Wiggert.

Power Generation

F. A. Allner, Chairman, Lexington Building, Baltimore, Md.

J. R. Baker, Secretary, 1611 Lexington Building, Baltimore, Md.

F. A. Annett,
T. J. Bostwick,
J. B. Crane,
H. W. Eales,
N. E. Funk,
D. L. Galusha,
R. B. Gerhardt,
W. S. Gorsuch,
F. C. Hanker,
C. F. Hirshfeld,
F. H. Hollister,
A. H. Hull,
G. A. Jessop,
H. W. Leitch,
E. B. Meyer,
E. L. Moreland,
I. E. Moultrop,
G. E. Quinan,
F. A. Scheffler,
A. E. Silver,
W. F. Sims,
A. R. Smith,
E. C. Stone,
R. W. Stovel.

Power Transmission and Distribution

P. H. Chase, Chairman, Philadelphia Electric Co., 900 Sansom St., Philadelphia, Pa.

R. N. Conwell, Vice-Chairman.

E. T. J. Brandon,
C. I. Burkholder,
A. B. Campbell,
C. V. Christie,
O. G. C. Dahl,
Harold C. Dean,
L. L. Elden,
H. S. Evans,
R. D. Evans,
F. M. Farmer,
J. H. Foote,
L. F. Hickernell,
K. A. Hawley,
J. P. Jollyman,
A. H. Lawton,
L. L. Perry,
T. F. Peterson,
D. W. Roper,
A. E. Silver,
D. M. Simmons,
C. T. Sinclair,
L. G. Smith,
Philip Sporn,
C. F. Wagner,
H. S. Warren,
T. A. Worcester.

Protective Devices

Raymond Bailey, Chairman, Philadelphia Electric Co., 900 Sansom St., Philadelphia, Pa.

L. E. Frost, Secretary, Brooklyn Edison Co., 380 Pearl St., Brooklyn, N. Y.

J. E. Allen,
A. C. Cummins,
H. W. Drake,
W. S. Edsall,
W. W. Edson,
L. E. Frost,
E. E. George,
H. Halperin,
F. C. Hanker,
E. A. Hester,
L. F. Hickernell,
M. G. Lloyd,
J. P. McKearin,
H. A. McLaughlin,
A. M. Rossman,
A. H. Schirmer,
H. K. Sels,
H. P. Sleeper,
E. R. Stauffacher,
H. R. Summerhayes,
E. M. Wood,
H. B. Wood.

Research

L. W. Chubb, Chairman, W. E. & M. Co., East Pittsburgh, Pa.

H. D. Arnold,
Edward Bennett,
W. G. Cady,
E. H. Colpitts,
E. C. Crittenden,
W. F. Davidson,
W. P. Dobson,
F. M. Farmer,
J. Allen Johnson,
V. Karapetoff,
A. E. Kennelly,
J. K. McNeely,
F. W. Peek, Jr.,
Hubert H. Race,
C. W. Rice,
D. W. Roper,
T. Spooner,
J. B. Whitehead.

Transportation

Sidney Withington, Chairman, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

Philip P. Ash,
Reinier Beeuwkes,
A. E. Bettis,
J. V. B. Duer,
H. H. Field,
Ira W. Fisk,
W. A. Giger,
K. T. Healy,
D. C. Jackson,
John Murphy,
Ivan Ofverholm,
H. Parodi,
W. B. Potter,
Ralph H. Rice,
A. S. Richey,
S. A. Spalding,
N. W. Storer,
W. M. Vandersluis.
Richard H. Wheeler,
R. P. Winton,
G. I. Wright.

INSTITUTE REPRESENTATIVES

Alfred Noble Prize Committee

A. E. Knowlton.

American Association for the Advancement of Science Council

O. J. Ferguson,
C. E. Skinner.

American Bureau of Welding

H. M. Hobart.

American Committee on Electrolysis

B. J. Arnold,
N. A. Carle,
F. N. Waterman.

American Engineering Council Assembly

A. W. Berresford,
C. O. Bickelhaupt,
F. J. Chesterman,
M. M. Fowler,
F. L. Hutchinson,
H. A. Kidder,
W. S. Lee,
William McClellan,
L. F. Morehouse.
I. E. Moultrop,
Farley Osgood,
W. S. Rodman,
R. F. Schuchardt,
Charles F. Scott,
C. E. Skinner,
Harold B. Smith,
C. E. Stephens.
L. B. Stillwell,

American Marine Standards Committee

R. A. Beekman.

American Standards 'Association

F. D. Newbury,
John C. Parker,
L. T. Robinson.

H. H. Henline,
H. M. Hobart,
H. S. Osborne, Alternates.

American Year Book, Advisory Board

Henry H. Henline.

Charles A. Coffin Fellowship and Research Fund Committee

W. S. Lee.

Committee of Apparatus Makers and Users, National Research Council

C. E. Skinner.

Committee on Elimination of Fatigue, Society of Industrial Engineers

C. Francis Harding.

Committee on Heat Transmission, National Research Council

T. S. Taylor.

Engineering Foundation, Inc.

H. P. Charlesworth, H. A. Kidder,
G. L. Knight.

Engineering Societies Monographs Committee

E. B. Meyer, W. I. Slichter.

Engineering Societies Research Board

Gano Dunn, C. E. Skinner.

Hoover Medal Committee

Gano Dunn, F. B. Jewett,
E. W. Rice, Jr.

John Fritz Medal Board of Award

Bancroft Gherardi, R. F. Schuchardt,
W. S. Lee, Harold B. Smith.

Joint Committee on Welded Rail Joints

D. D. Ewing.

Joint Conference Committee of Founder Societies

The Presidents and Secretaries, *ex-officio*.

Library Board, Engineering Foundation, Inc.

Edward D. Adams, F. L. Hutchinson,
W. A. Del Mar, W. B. Jackson,
W. I. Slichter.

National Fire Protection Association, Electrical Committee

A. W. Berresford, F. V. Magalhaes,
Alternate.

National Fire Waste Council

A. W. Berresford, F. V. Magalhaes.

National Research Council, Engineering Division

F. B. Jewett, F. W. Peek, Jr.,
C. E. Skinner.
F. L. Hutchinson, *ex-officio*.

National Safety Council, Electrical Committee

A. S. S. E.—Engineering Section

A. W. Berresford.

Radio Advisory Committee, Bureau of Standards

A. E. Kennelly.

U. S. National Committee of th International Commission on Illumination

A. E. Kennelly, C. O. Mailloux,
Clayton H. Sharp.

U. S. National Committee of th International Electrotechnical Commission

E. W. Allen,
W. A. Del Mar,
Gano Dunn,
F. C. Hanker,
C. R. Harte,
H. M. Hobart,
D. C. Jackson,
F. B. Jewett,
A. E. Kennelly,
W. S. Lee (*ex-officio*),
C. O. Mailloux,
William McClellan,
J. F. Meyer,
F. D. Newbury (*ex-officio*),
H. S. Osborne,
Farley Osgood,
F. W. Peek, Jr.,
Harold Pender,
L. T. Robinson,
C. H. Sharp,
C. E. Skinner,
W. I. Slichter,
C. E. Stephens (*ex-officio*),
N. W. Storer,
John W. Upp.

Commission of Washington Award

L. A. Ferguson Charles F. Scott

GEOGRAPHICAL DISTRICT EXECUTIVE COMMITTEES

District	Chairman (Vice-President, A. I. E. E.)	Secretary (District Secretary)
No. 1—North Eastern	I. E. Moultrop, Edison Elec. Illum. Co., 39 Boylston St., Boston	A. C. Stevens, General Electric Co., Schenectady
No. 2—Middle Eastern	E. C. Stone, Duquesne Light Co., 435 Sixth Ave., Pittsburgh	J. A. Cadwallader, Bell Tel. Co. of Pa., 416 Seventh Ave, Pittsburgh
No. 3—New York City	H. P. Charlesworth, 463 West St., New York	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York
No. 4—Southern	W. S. Rodman, Box 675, University, Va.	J. S. Miller, Jr., Box 12, University, Va.
No. 5—Great Lakes	T. N. Lacy, Mich. Bell Tel. Co., 1365 Cass Ave., Detroit	A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis
No. 6—North Central	Herbert S. Evans, University of Colorado, Boulder, Colo.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. C. Shaad, University of Kansas, Lawrence, Kans.	Robert W. Warner, University of Kansas, Lawrence, Kans.
No. 8—Pacific	C. E. Fleager, Pac. Tel. & Tel. Co., 140 New Montgomery St., San Francisco	H. W. Hitchcock, 1050 Telephone Bldg., 740 South Olive St., Los Angeles
No. 9—North West	H. V. Carpenter, State College of Washington, Pullman, Wash.	R. D. Sloan, State College of Washington, Pullman, Wash.
No. 10—Canada	C. E. Sisson, Canadian Gen. Elec. Co., 1025 Lansdowne Ave., Toronto, Ont.	W. L. Amos, Hydro-Elec. Pr. Com., 190 University Ave., Toronto, Ont.

Note: Each District Executive Committee includes the chairmen and secretaries of all Sections within the District and the chairman of the District Committee on Student Activities.

LOCAL SECTIONS OF THE INSTITUTE

Name	District	Chairman	Secretary	Secretary's Address
Akron	2	H. C. Paiste	Alvin P. Regal	Phila. Rubber Works Co., Akron, Ohio
Atlanta	4	H. C. Uhl	O. O. Rae	Westinghouse E. & M. Co., Atlanta, Ga.
Baltimore	2	W. B. Kouwenhoven	J. Wells	Western Elec. Co., 25 Broening Rd., Baltimore, Md.
Birmingham	4		O. E. Charlton	Allied Engineers, Inc., Birmingham, Ala.
Boston	1	J. P. Kobrock	G. J. Crowdes	Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
Chicago	5	F. H. Lane	L. R. Mapes	Ill. Bell Tel. Co., 212 W. Washington St., Chicago, Ill.
Cincinnati	2	T. C. Reed	L. L. Bosch	Columbia Eng. & Mgt. Corp., 314 West 4th St., Cincinnati, Ohio
Cleveland	2	F. W. Braund	John M. Smith	Nela Park, Cleveland, Ohio
Columbus	2	C. D. Price	K. Y. Tang	Ohio State University, Columbus, Ohio
Connecticut	1	Samuel Ferguson	R. G. Warner	Yale Univ., 10 Hillhouse Ave., New Haven, Conn.
Dallas	7	L. T. Blaisdell	G. A. Dyer	Southwestern Bell Tel Co., Dallas, Texas
Denver	6	R. B. Bonney	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	LeRoy Braisted	J. J. Shoemaker	Detroit Edison Co., 2000-2nd Ave., Detroit, Mich.
Erie	2	G. R. McDonald	G. I. LeBaron	General Elec. Co., Erie, Pa.
Fort Wayne	5	W. J. Morrill	C. M. Summers	General Elec. Co., Fort Wayne, Ind.
Houston	7	C. D. Farman	Hezzie Clark	Humble Pipe Line Co., Drawer, 1761, Houston, Texas
Indianapolis-Laf	5	E. G. Ralston	C. E. Dutton	Am. Tel. & Tel. Co., 256 N. Meridian St., Indianapolis, Ind.
Iowa	5	J. K. McNeely	H. B. Hoffhaus	Des Moines El. Lt. Co., 312-6th Ave., Des Moines, Iowa
Ithaca	1	W. C. Ballard, Jr.	W. E. Meserve	614 E. Buffalo St., Ithaca, N. Y.
Kansas City	7	J. S. Palmer	Richard M. Ryan	510 Dwight Bldg., Kansas City, Mo.
Lehigh Valley	2	W. M. Harbaugh	J. H. Diefenderfer	Penn. Pr. & Lt. Co., Hazleton, Pa.
Los Angeles	8	H. W. Hitchcock	Philip S. Biegler	3551 University Ave., Los Angeles, Calif.
Louisville	4	James Clark, Jr.	Philip P. Ash	L. & N. R. R. Bldg., 9th and Broadway Ave., Louisville, Ky.
Lynn	1	A. L. Ellis	W. K. Dickinson	General Elec. Co., West Lynn Works, Lynn, Mass.

LOCAL SECTIONS OF THE INSTITUTE—*Continued*

Name	District	Chairman	Secretary	Secretary's Address
Madison	5	L. C. Larson	G. F. Tracy	Elec. Lab. Bldg., Univ. of Wisconsin, Madison, Wis.
Memphis	4	M. Eldredge	W. A. Gentry	Memphis Pr. & Lt. Co., Memphis, Tenn.
Mexico	3	B. E. Arias	L. Castro, Jr	Departamento Electricidad y Telegrafos, Ferrocarriles Nacionales de Mexico, Mexico, D. F.
Milwaukee	5	F. A. Kartak	I. L. Illing	Milwaukee El. Ry. & Lt. Co., 380 Pub. Serv. Bldg., Milwaukee, Wis.
Minnesota	5	D. K. Lewis	H. J. Pierce	Northwestern Bell Tel. Co., Minneapolis, Minn.
Nebraska	6	W. O. Jacobi	A. L. Turner	1112 Telephone Bldg., Omaha, Nebraska
New York	3	J. B. Bassett	C. R. Jones	Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
Niagara Frontier	1	E. S. Bundy	G. W. Eighmy	General Elec. Co., 1100 Elec. Bldg., Buffalo, N. Y.
North Carolina	4	J. H. Paget	F. C. DeWeese	Carolina Pr. & Lt. Co., Raleigh, N. C.
Oklahoma City	7	F. J. Meyer	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	D. H. Kelly	J. L. MacBurney	El. St. Bat. Co., 1955 Hunting Park Ave., Phila., Pa.
Pittsburgh	2	C. T. Sinclair	F. A. Connor	General Elec. Co., 1309 Oliver Bldg., Pittsburgh, Pa.
Pittsfield	1	C. H. Kline	L. H. Burnham	General Electric Co., Pittsfield, Mass.
Portland, Ore	9	A. H. Kreul	C. W. Fick	General Electric Co., Portland, Oregon
Providence	1	J. W. Young	O. W. Briden	Blackstone Valley G. & E. Co., 231 Main St., Pawtucket, R. I.
Rochester	1	Harvey J. Klumb	F. C. Young	Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
St. Louis	7	C. B. Fall	E. A. Forkner	Wagner Elec. Corp., 6400 Plymouth Ave., St. Louis, Mo.
San Antonio	7	D. W. Flowers	E. Bissett	San Antonio P. S. Co., 201 N. St., Mary St., San Antonio, Texas
San Francisco	8	P. B. Garrett	E. F. Maryatt	Pacific G. & E. Co., 245 Market St., San Francisco, Calif.
Saskatchewan	10	W. T. Hunt	A. B. Coward	Light and Power Dept., Regina, Sask., Canada
Schenectady	1	E. S. Henningsen	E. P. Nelson	D. C. Eng. Dept. General Elec. Co., Schenectady, N. Y.
Seattle	9	C. E. Carey	Philip D. Jennings	5560 Stuart Bldg., Seattle, Wash.
Sharon	2	S. S. Cook	R. M. Field	Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	4	J. H. Berry	Cecil Gray	Westinghouse E. & M. Co., 912 El. Bldg., Richmond, Va.
Spokane	9	Loren A. Traub	C. F. Norberg	Washington Water Pr. Co., Spokane, Wash.
Springfield, Mass	1	J. N. Alberti	L. C. Packer	Westinghouse E. & M. Co., Page Blvd., Springfield, Mass.
Syracuse	1	F. E. Verdin	Charles W. Henderson	504 University Pl., Syracuse, N. Y.
Toledo	2	F. H. Dubs	Max Neuber	1257 Fernwood Ave., Toledo, Ohio
Toronto	10	D. A. McKenzie	G. D. Floyd	Hydro El. Pr. Comm., 190 Univ. Ave., Toronto, Ont.
Urbana	5	C. E. Skroder	W. J. Putnam	123 Mat. Test. Lab. Univ. of Illinois, Urbana, Ill.
Utah	9	L. B. Fuller	Paul Ranson	Utah Apex Mining Co., Bingham Canyon, Utah
Vancouver	10	H. Vickers	C. Arnott	B. C. E. Ry. Co., Ltd., 425 Carrall St., Vancouver, B. C.
Washington	2	George W. Vinal	J. L. Carr	General Elec. Co., 800-15th St., N. W., Washington, D. C.
Worcester	1	J. K. Oldham	R. P. Bullen	General Elec. Co., Worcester, Mass.
Total 58				

STUDENT BRANCHES OF THE INSTITUTE

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Univ. of	Akron, Ohio	2	Harmon Shively	H. H. Schroeder	J. T. Walther
Alabama Poly. Inst	Auburn, Ala	4	J. A. Willman	P. C. Avant	W. W. Hill
Alabama, Univ. of	University, Ala	4	Walter H. Croft	Harold B. Hendrix	F. R. Maxwell, Jr.
Arizona, Univ. of	Tucson, Ariz	8	W. T. Brinton	Carl Ludy	J. C. Clark
Arkansas, Univ. of	Fayetteville, Ark	7	Ned S. Muse	E. Wylie Head	W. B. Stelzner
Armour Inst. of Tech	Chicago, Ill	5	K. A. Knittel	E. Squires	D. E. Richardson
British Columbia, Univ. of	Vancouver, B. C	10	M. A. Thomas	E. M. Kershaw	E. G. Cullwick
Brooklyn, Poly. Inst. of	Brooklyn, N. Y	3	George Morton	F. Anderson	Robin Beach
Bucknell Univ	Lewisburg, Pa	2	O. R. Sterling	P. Hort	W. K. Rhodes
Calif. Inst. of Tech	Pasadena, Calif	8	A. W. Strong	J. E. Girard	R. W. Sorensen
Calif., Univ. of	Berkeley, Calif	8	Harry C. Stanley	Louis Zable	L. E. Reukema
Carnegie Inst. of Tech	Pittsburgh, Pa	2	M. W. Smedberg	G. H. Ikola	G. Porter
Case Sch. of Ap. Science	Cleveland, Ohio	2	G. A. Sanow	Irwin J. Rand	H. B. Dates
Catholic Univ. of America	Washington, D. C	2			T. J. MacKavanagh
Cincinnati, Univ. of	Cincinnati, Ohio	2	F. F. Osterholtz	Henry Suter	W. C. Osterbrock
Clarkson College of Tech	Potsdam, N. Y	1	E. S. Whitaker	C. L. Brown	A. R. Powers
Clemson Agri. College	Clemson College, S. C	4	C. E. Jarrard	G. A. Douglass	S. R. Rhodes
Colorado, State Agri. College	Ft. Collins, Colo	6	Henry Wamboldt	L. Dougherty	F. L. Poole
Colorado, University of	Boulder, Colo	6	R. Partington	John Buffo	W. C. DuVall
Cooper Union	New York, N. Y	3	H. Grissler	A. B. Mundel	A. J. B. Fairburn
Cornell University	Ithaca, N. Y	1	C. O. Dean	Wm. E. Brainard	E. M. Strong
Denver, Univ. of	Denver, Colo	6	Harry H. Ward	Fay Olmsted	R. E. Nyswander
Detroit, Univ. of	Detroit, Michigan	5	W. R. Moyers	L. F. Ross	H. O. Warner
Drexel Inst	Philadelphia, Pa	2	E. K. Oliver	G. R. Bowers	E. O. Lange
Duke Univ	Durham, N. C	4	L. R. Ransom		W. J. Seeley
Florida, Univ. of	Gainesville, Fla	4	C. V. Booth	E. Menendez	Joseph Weil
Georgia School of Tech	Atlanta, Ga	4	B. L. Palmer	H. A. List	T. W. Fitzgerald
Harvard University	Cambridge, Mass	1	J. H. Wright	P. R. Lincoln	C. L. Dawes
Idaho, Univ. of	Moscow, Idaho	9	F. Meneely	Clyde Ross	J. H. Johnson
Iowa State College	Ames, Iowa	5	George A. Estel	A. W. Chewning	F. E. Johnson
Iowa, State Univ. of	Iowa City, Iowa	5	J. Westley Campian	D. A. Cozine	E. B. Kurtz
Kansas State College	Manhattan, Kansas	7	H. E. Trekell	E. W. Bennett	R. G. Kloeffler
Kansas, Univ. of	Lawrence, Kansas	7	Harry Immich	DeWayne Nolting	D. C. Jackson, Jr.
Kentucky, Univ. of	Lexington, Ky	4	S. M. Worthington	B. G. Crosby, Jr	W. E. Freeman
Lafayette College	Easton, Pa	2	A. H. Edmondson	H. H. Jones	Morland King
Lehigh Univ	Bethlehem, Pa	2	P. W. Seal	L. R. Wanner	N. S. Hibshman

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Lewis Inst	Chicago, Ill	5	C. B. Frellsen	K. J. Sinclair	F. A. Rogers
Louisiana State Univ	Baton Rouge, La	4	Fred H. Fenn	R. A. Crain	M. B. Voorhies
Louisville, Univ. of	Louisville, Ky	4	John G. Lips	Wm. E. Bailey	S. T. Fife
Maine, Univ. of	Orono, Maine	1	Monroe E. Moon	Lincoln O. Spencer	W. E. Barrows, Jr.
Marquette Univ	Milwaukee, Wis	5	David Becker	Edward Halback	Edward Kane
Massachusetts Inst. of Tech	Cambridge, Mass	1	G. S. Brown	Fred J. Elser	W. H. Timbie
Michigan Col. of Mining and Tech	Houghton, Mich	5	A. G. Rogers	M. D. Crowell	G. W. Swenson
Michigan State College	East Lansing, Mich	5	Robert Dearing	J. J. Clark	W. A. Murray
Michigan, Univ. of	Ann Arbor, Michigan	5	A. D. Forbes	G. Muffly	B. F. Bailey
Milwaukee, School of Eng. of	Milwaukee, Wis	5	William P. Gainer	H. F. Volkmann	Oscar Werwath
Minnesota, Univ. of	Minneapolis, Minn	5	Wesley D. Taylor	R. C. Cady	J. H. Kuhlmann
Mississippi Agri. & Mech. Col	A. & M. College, Miss	4	J. M. Leigh	J. T. Young	L. L. Patterson
Missouri School of Mines & Met	Rolla, Mo	7	J. D. Shelton	G. L. Leisher	I. H. Lovett
Missouri, Univ. of	Columbia, Mo	7	R. L. Young	Walter Sevchuk	M. P. Weinbach
Montana State College	Bozeman, Mont	9	Bruce Mull	Wm. McKay	J. A. Thaler
Nebraska, Univ. of	Lincoln, Nebraska	6	V. L. Bollman	W. E. Stewart	F. W. Norris
Nevada, Univ. of	Reno, Nevada	8	Francis Headley	Eugene Tucker	S. G. Palmer
Newark College of Eng	Newark, N. J	3	Wm. R. Ackor	John G. Woelking	J. C. Peet
New Hampshire, Univ. of	Durham, N. H	1	A. K. Whitcomb	Carl B. Evans	L. W. Hitchcock
New Mexico, Univ. of	Albuquerque, New Mexico	7	C. E. Henderson	S. M. Pelatowski	F. M. Denton
New York, Col. of the City of	New York, N. Y	3	Joseph Preuss	Howard Klein	Harry Baum
New York Univ	Univ. Heights, New York, N. Y	3	G. J. Helis	M. Bogstahl	J. L. Arnold
North Carolina State College	Raleigh, N. C	4	R. C. Kirk	J. H. Mauney	R. S. Fouraker
North Carolina, Univ. of	Chapel Hill, N. C	4	G. D. Thompson	Charles Hayes	J. E. Lear
North Dakota Agri. College	Fargo, N. D	6	R. Stockstad	R. Carlson	H. S. Rush
North Dakota, Univ. of	Grand Forks, N. D	6	C. J. Breitwieser	R. C. McConnell	H. F. Rice
Northeastern Univ	Boston, 17, Mass	1	A. K. Wright	P. H. Townsend	W. L. Smith
Notre Dame, Univ. of	Notre Dame, Ind	5	Earl Brieger	H. J. Perry	J. A. Caparo
Ohio Northern Univ	Ada, Ohio	2	D. Pringle	H. L. Hartman	W. Krausnick
Ohio State Univ	Columbus, Ohio	2	G. F. Leydorf	R. W. Steenrod	F. C. Caldwell
Ohio Univ	Athens, Ohio	2	H. Swigart	H. Adcock	A. A. Atkinson
Oklahoma Agri. & Mech. Col	Stillwater, Okla	7	Paul H. Foster	Merle C. Brady	A. Naeter
Oklahoma, Univ. of	Norman, Okla	7	G. S. Hammonds	William J. Fell	F. G. Tappan
Oregon State College	Corvallis, Oregon	9	H. Glen Barnett	Gordon N. Smith	F. O. McMillan
Pennsylvania State College	State College, Pa	2	S. E. McKibben	E. L. Johnston	L. A. Doggett
Pennsylvania, Univ. of	Philadelphia, Pa	2	Wm. D. Bruce	C. V. Castle	C. D. Fawcett
Pittsburgh, Univ. of	Pittsburgh, Pa	2	W. J. Howell	R. H. Kernahan	H. E. Dyche
Pratt Inst	Brooklyn, N. Y	3	J. E. Cook	J. A. Hoag	C. C. Carr
Princeton Univ	Princeton, N. J	2		Ernest E. George	M. MacLaren
Purdue Univ	Lafayette, Ind	5	A. Simon	C. B. Bruse	A. N. Topping
Rensselaer Poly. Inst	Troy, N. Y	1	C. E. Keeler	A. M. Lockie	F. M. Sebast
Rhode Island State College	Kingston, R. I	1	G. Z. Verros	M. R. Lettieri	Wm. Anderson
Rose Poly. Inst	Terre Haute, Indiana	5			C. C. Knipmeyer
Rutgers Univ	New Brunswick, N. J	3	F. T. Kent, Jr	R. C. Howell	P. S. Creager
Santa Clara, Univ. of	Santa Clara, Calif	8	William Warren	L. W. Thorpe	E. F. Petersen
South Carolina, Univ. of	Columbia, S. C	4	H. L. Stokes	Anderson Riley	T. F. Ball
South Dakota State Sch. of Mines	Rapid City, S. D	6	C. Laws	A. M. Bjerke	J. O. Kammerman
South Dakota, Univ. of	Vermillion, S. D	6	Myron Cole	Carl Bauman	B. B. Brackett
Southern California, Univ. of	Los Angeles, Calif	8	Rodney Lewis	J. G. Ellis	Wm. G. Angermann
Southern Methodist Univ	Dallas, Texas	7	F. H. Gable	P. Lindsley, Jr	H. F. Huffman
Stanford Univ	Stanford University, Calif	8	V. Siegfried	G. E. J. Jamart	T. H. Morgan
Stevens Inst. of Tech	Hoboken, N. J	3	G. J. Costello		F. C. Stockwell
Swarthmore College	Swarthmore, Pa	2	Lewis Fussell, Jr	Robert H. Lamey	L. Fussell
Syracuse Univ	Syracuse, N. Y	1	Donald Robinson	W. Kleppinger	C. W. Henderson
Tennessee, Univ. of	Knoxville, Tenn	4	A. M. Howery	B. A. Cogbill	J. G. Tarboux
Texas Agri. & Mech. Col	College Station, Tex	7	T. M. Sowell	E. A. Stobart	H. C. Dillingham
Texas Tech. College	Lubbock, Texas	7	Walter Burns	Everitt Dison	Wm. J. Miller
Texas, Univ. of	Austin, Texas	7	L. M. Curry	Bayron Lindley	J. A. Correll
Utah, Univ. of	Salt Lake City, Utah	9	Fred Lundberg	Ray Bohne	J. H. Hamilton
Vermont, Univ. of	Burlington, Vt	1	R. F. Bigwood	P. H. Thomas	L. P. Dickinson
Virginia Military Inst	Lexington, Va	4	G. R. Shell	C. L. Wills	S. W. Anderson
Virginia Poly. Inst	Blacksburg, Va	4	C. V. West	R. E. McDaniel	Claudius Lee
Virginia, Univ. of	University, Va	4	G. G. Quarles	E. H. Williamson	W. S. Rodman
Washington, State Col. of	Pullman, Wash	9	L. Engvall	E. W. Graf	O. E. Osburn
Washington Univ	St. Louis, Mo	7	J. Pillsbury	P. Grivet	H. G. Hake
Washington, Univ. of	Seattle, Wash	9	K. H. Ellerbeck	F. Buckman	G. L. Hoard
West Virginia Univ	Morgantown, W. Va	2	P. J. Johnson	C. F. Stewart	A. H. Forman
Wisconsin, Univ. of	Madison, Wis	5	A. G. Woodford		C. M. Jansky
Worcester Poly. Inst	Worcester, Mass	1	Albert M. Demont	William Sinclair	J. O. Phelon
Wyoming, Univ. of	Laramie, Wyo	6	J. Earl Mowry	Cyril F. Horton	G. H. Sechrist
Yale Univ	New Haven, Conn	1	E. R. Eberle	L. A. Autuori	W. B. Hall
Total 107					

AFFILIATED STUDENT SOCIETY

Brown Engineering Society	Brown Univ., Providence, R. I.

ORDER FORM FOR REPRINTS OF PAPERS ABRIDGED IN THIS ISSUE OF "ELECTRICAL ENGINEERING"*

(January 1931)

Number	Author	Title
☐ **30-175**	S. Logan Kerr	Automatic Operator for Economy Control Applied to Hydroelectric Generator Stations
☐ **30-179**	F. W. Cartland	Lighting Airway Beacons Direct from High-Voltage Transmission Lines
☐ **30-180**	R. C. Buell, R. J. Caughey, E. M. Hunter and V. M. Marquis	Governor Performance During System Disturbances
☐ **30-185**	J. Elmer Housley	Lightning Investigation at Alcoa, Tenn.

***Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its JOURNAL publication. Thereafter a charge of twenty-five cents per complete copy will obtain.**

Name..

Address..

Please order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Industrial Notes

Condit Offices in New Home.—The Condit Electrical Manufacturing Corporation has moved its sales and executive offices to the new administration building at Hyde Park, Mass.

Electrad Appoints Millard Van Blaricom.—The development of its amplifier business necessitating the enlargement of the technical staff, Millard Van Blaricom, expert in amplifying systems, has been appointed, according to a statement by Arthur Moss, president of Electrad, Inc., New York.

Westinghouse in Refrigeration Field.—Distribution of the Westinghouse refrigerator to all parts of the United States east of Kansas City will be begun at once, according to an announcement by Carl D. Taylor, manager of the refrigeration department of the Westinghouse Electric and Manufacturing Company. During 1930 the refrigerator has been distributed and sold in a gradually increasing area in the east.

Roebling Absorbs New Jersey Wire Cloth Company.—According to a recent announcement, the New Jersey Wire Cloth Company will cease its corporate existence on January 1, and the business will be continued by the John A. Roebling's Sons Company. The New Jersey Wire Cloth Company, now a subsidiary of the Roebling Company, manufactures wire cloth, wire netting, wire fences, etc., the sale of which will be continued through the parent company and other Roebling branches.

Grounding Devices.—Bulletin, 36 pp., "Principles of Grounding." Presents methods of grounding electrical apparatus and auxiliary equipment. A typical ground bus for an outdoor substation is illustrated, embodying recommendations of N. E. L. A. committees. Types of Burndy connectors for diverse applications are shown, as well as connectors used for copper or aluminum tube, cable or bar. Burndy Engineering Co., Inc., 230 East 45th Street, New York.

New G. E. Plastic Department.—The various plastic activities of the General Electric Company have been coordinated into one department known as the plastic department according to an announcement by Gerard Swope, president of the company. R. E. Coleman has been appointed manager of the new department with an advisory committee consisting of vice-presidents J. G. Barry, chairman, W. R. Burrows, and C. E. Eveleth. The new department will be responsible for sales, engineering and manufacturing of plastics and involves activities at the Pittsfield, Schenectady, Fort Wayne, Erie and Lynn (River) plants of the company.

New Power Amplifiers.—Electrad, Inc., 175 Varick Street, New York, has announced the addition of two newly perfected power amplifiers utilizing the revolutionary Loftin-White direct-coupled system which, with their model A-245, completes a line of amplifiers suitable for the present-day requirements of sound amplification of all types. These Electrad direct-coupled amplifiers are readily adaptable to all usual requirements of sound amplification from microphones, phonograph pickups, radio tuners—in fact for all types of amplification at audio frequencies.

NEMA Opposes One Form of Bids on Electrical Equipment.—Opposition to the practice of requiring detailed working drawings with bids on electrical equipment or as an element of contract, was expressed in a resolution adopted November 21 by the Executive Committee of the National Electrical Manufacturers Association. The resolution is as follows:

WHEREAS: The practice of requiring detailed working drawings with bids or as an element of contract is objectionable and works a hardship on the manufacturer in that there is involved not merely unnecessary expense, but the demand for information and data which are the result of knowledge and experience, and are major elements of the bidder's "Stock in trade," be it RESOLVED: That the National Electrical Manufacturers Association hereby records its formal opposition to the practice.

This opposition does not apply to such outline drawings of apparatus showing overall dimensions, assembly drawings of major components, wiring diagrams, performance data and other diagrams, charts, photographs and instructions as are needed for installation, operation and maintenance purposes.

Trade Literature

Illumination.—Booklet L. P. 102, 40 pp., entitled "Tendencies in Lighting Practice, 1930." Illustrated. General Electric Company, Nela Park, Cleveland, Ohio.

Steam Generating Equipment.—Catalog GC-6, 16 pp. Describes and illustrates the fuel burning and steam generating equipment manufactured by the Combustion Engineering Corporation, 200 Madison Avenue, New York.

Automatic Controller Valves.—Catalog 2002, 20 pp. Describes Bristol's automatic controller valves, motor operated types, including the latest developments for steam, water, air and gas. The Bristol Company, Waterbury, Conn.

The Coordination of Light and Music.—Bulletin L. P. 101, 24 pp. Describes the application of color lighting in motion picture theatres. General Electric Company, Nela Park, Cleveland, Ohio.

Fuse Meter Service Switch.—Bulletin 23, 4 pp. Describes Wadsworth accessible fuse meter switch with range and lighting circuits for new and old residence wiring. Wadsworth Electric Manufacturing Co., Inc., Covington, Ky.

Cars and Car Equipment.—Bulletin 1882, 32 pp. Describes and illustrates twenty-six types of street cars and buses placed in service within the last two years. Westinghouse Electric & Manufacturing Corporation, East Pittsburgh, Penna.

Ash Storage Tanks.—Bulletin, 16 pp. Describes vitrified glazed tile, ash storage tanks, providing complete facilities of ash storage for all types of ash conveyor systems. United Conveyor Corporation, Old Colony Building, Chicago, Ill.

Automatic Reclosing Equipment.—Bulletin 20508, 4 pp. Describes Westinghouse type FO-22 outdoor automatic reclosing equipment, designed for use on feeder circuits. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penna.

Tachometers.—Catalog 46, 16 pp. Describes Brown electric indicating and recording tachometers. These instruments consist of the indicating, recording or automatic control instrument, tachometer generator, wiring between generator and instrument. The generator can be connected to the driving shaft through gears, pulleys, chain or flexible coupling. The Brown Instrument Company, Philadelphia, Penna.

Small Motors.—Bulletin 1883, 16 pp. Describes the various types of Westinghouse small power motors. Illustrations show the construction details of the motors and some of their many applications. Another feature of this publication is a description of the sentinal breaker, a compact starting switch that provides overload protection for fractional horsepower motors. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penna.

Electrical Engineering

THE

JOURNAL of the A. I. E. E.

Volume 50 FEBRUARY, 1931 Number 2

Published Monthly by the

AMERICAN INSTITUTE
of
ELECTRICAL ENGINEERS

33 West 39th Street, New York

Copyright 1931

William S. Lee, *President*
F. L. Hutchinson, *National Secretary*

PUBLICATION COMMITTEE
W. S. Gorsuch, *Chairman*
H. P. Charlesworth A. E. Knowlton
F. L. Hutchinson E. B. Meyer

PUBLICATION STAFF
George R. Metcalfe, *Editor*
G. Ross Henninger, *Assoc. Editor*
C. A. Graef, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

Entered as second class matter at the N. Y. Post Office, May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

Permission is given to reprint any Institute article or paper provided full credit is given.

The Institute is not responsible for any statements made or opinions expressed in its publications.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America.

In This Issue—

Front Cover

New 220-kv. transmission line of the Public Service Electric and Gas Company, New Jersey, between Roseland and Plymouth Meeting substations; placed in service Sept. 1, 1930. Tower is 34 x 39 ft. at base and 78 ft. high giving 59-ft. conductor clearance at the tower; average span, 1,100 ft.

Electric Power in the Lumber Industry 92
By A. H. Onstad, *Weyerhaeuser Timber Company*

Mercury Rectifiers for Subway Service 97
By H. M. VanGelder, *Dept. of City Transit, Philadelphia*

Electrolysis Survey at Louisville, Kentucky . . 100
By W. C. White, *Southern Bell Tel. & Tel. Company*

Fog-Type Insulators Eliminate Flashovers . . . 101

Railroads vs. Transmission Lines 102
By W. W. Woodruff, *Philadelphia Electric Company and* G. I. Wright, *Reading Company*

Synchronizing with Vacuum Tubes 105

Saturation Phenomena in Potential Transformers 106
By C. T. Weller, *General Electric Company*

Physical Nature of Neutral Instability 110
By A. Boyajian *and* O. P. McCarty, *both of General Electric Company*

Progress in Fuel Utilization 113

—Turn to Next Page—

Theory of Abnormal Voltages 114

By C. W. LaPierre, *General Electric Company*

Graphical Construction of Hyperbolic Functions . 117

By W. F. Helwig, *Texas Technological College*

Greater Efficiency for Low-Head Hydro 118

By George A. Jessop, *S. Morgan Smith Company* and C. A. Powell, *Westinghouse Elec. & Mfg. Company*

Detecting Hidden Fissures in Rails 122

By H. C. Drake, *Sperry Products, Inc.*

The Engineer's Duty to Himself and to the Public . 125

By William S. Lee, *President, A. I. E. E.*

Control Groups Simplify Operation 128

By R. M. Stanley, *Byllesby Engineering & Management Corporation* and E. D. Wood, *Louisville Gas & Electric Company*

Magnetic Circuit Units Adopted by I. E. C . . . 133

By Arthur E. Kennelly, *Professor Emeritus, Harvard University*

Electric Welding in Modern Building Construction 133

The Oil-Blast Circuit Breaker 134

By D. C. Prince and W. F. Skeats, *both of General Electric Company*

News of Institute and Related Activities ◆ ◆ ◆ ◆ 138

Local Institute Meetings 151

Engineering Literature 157

Employment Notes 162

Membership 164

Officers and Committees 167

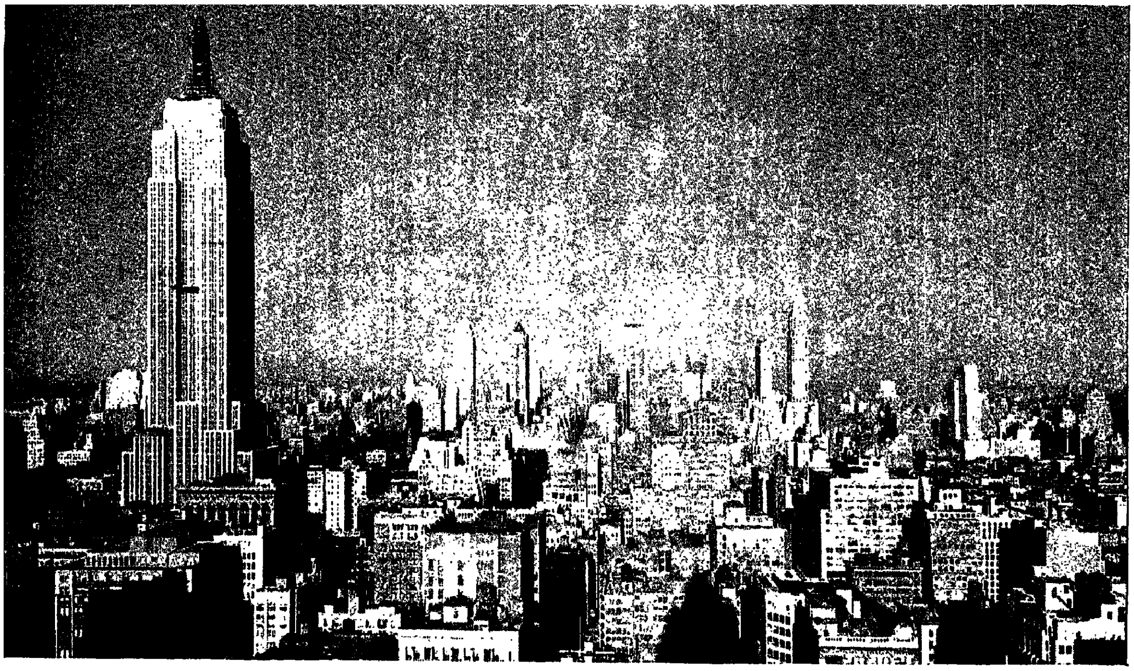
Industrial Notes 172

Dr. Arthur E.. Kennelly, professor emeritus of electrical engineering at Harvard University, past president A. I. E. E. (1896-1900), past president I. E. S. (1911), past president I. R. E. (1916), and well known both nationally and internationally for his versatility and untiring work for the betterment of the profession as applied to industry, comments further in this issue on the subject of internationally standardized magneti ccircuit units. *(See pages 133 and 141)*

W. S. Lee, president of the Institute, genial Southern gentleman, and conqueror of tremendous engineering undertakings, throws down the gauntlet in characteristic fashion in his declaration of "The Engineer's Duty to Himself and to the Public." Mr. Lee's wealth of engineering experience and his first-hand knowledge of men and affairs gives him a foundation from which to speak; his honest fearlessness enables him in an unimpassioned way to issue his challenge to his brother engineers. *(See page 125)*

D. C. Prince has made numerous discoveries and important contributions to the electrical engineering art. His studious application has carried him from a-c. motor developments to airplane machine gun design, and from radio engineering to mercury-arc rectifier research and design. His attention now is turned toward oil circuit breaker improvements. With the collaboration of W. F. Skeats he outlines important refinements in design which have led to the development of the oil-blast circuit breaker. *(See page 134)*

R. M. Stanley has been devoting his time and engineering talent to electrical utility design, operation, and economic problems for some twenty-three years. . He has been an aggressive leader in the promotion and adoption of engineering refinements in electric power equipment and has pioneered many of the paths now becoming familiar in the fields of remote control and automatic operation of major power producing and handling apparatus. One of his latest efforts is exemplified in the Ohio Falls hydroelectric generating station which he describes with the aid of E. D. Wood. *(See page 128)*



Winter Conventioners Viewed New York from its Newest Skyscraper, the 1,427-ft. Empire State Building (left).

ARAM BOYAJIAN for some time has been intimately associated with various phases of the stability problem as it involves electric power circuits and equipment. As a contributor to creative thought in this special field, Mr. Boyajian already has given considerable to active constructive debates at Institute gatherings. In this issue he discusses "The Physical Nature of Instability" in collaboration with O. P. McCarty. (*See page 110*)

◆

A. H. ONSTAD is a recognized Pacific Coast authority on electrification of lumber mills and incidental equipment. His accomplishments in this division of the field of electrical engineering well qualify him to speak upon the subject of "Electric Power in the Lumber Industry." (*See page 92*)

◆

PITTSBURGH, far-famed as America's steel city, asserts a just right to fame as an electrical engineering and electrical manufacturing center. The next district meeting on the Institute's calendar will be another Middle Eastern District meeting, to be held in Pittsburgh March 11-13, 1931. Many attractive features are offered. (*See page 138*)

◆

AN EXTENSIVE electrification program of the Reading Railroad in the Philadelphia area offered a definite opportunity for the joint use of a railroad right-of-way to accommodate both trains and electric power transmission lines. A combination of economic factors and engineering courage has established a noteworthy precedent. The installation is discussed by W. W. Wodruff and G. I. Wright. (*See page 102*)

◆

RECOMMENDATIONS covering seven specific items listed as having important bearing upon business' cyclic booms and recessions were made in a committee report presented to the American Engineering Council at its recent annual meeting in Washington, D. C. In addition to hearing the report the Council took a determined stand upon several important current and controversial legislative subjects of national interest. (*See page 148*)

◆

AS USUAL, the laboratory answers questions arising out of operating experience. In this issue there is given a comprehensive review of a symposium presenting facts and analyses pertaining to dangerous saturation phenomena which may occur in potential transformers, and to the causes of abnormal line voltages. C. T. Weller and C. W. LaPierre of the General Electric's general engineering laboratory present their findings as parts of a triad which includes a paper by A. Boyajian and O. P. McCarty. (*See pages 106, 110, 114*)

◆

A 1929 CENSUS of Manufactures, released by the U. S. Bureau of the Census, contains some facts and figures of current in spite of the fact that it is a year old upon release. (*See page 142*)

PROPELLER-type wheels with adjustable-blade features are opening up interesting possibilities in the direction of greater efficiency in low-head hydro plants. Experience and initiative both qualify G. A. Jessop and C. A. Powell to speak authoritatively upon this subject. (*See page 118*)

◆

"ENGINEERING LITERATURE" is the heading now used to embrace both the announcement of new books available at the Engineering Societies Library and the electrical engineering items selected each month from Engineering Index Service' listings of some 1,800 current technical periodicals. In connection with the typographical presentation of these latter items, a question has arisen concerning which a prompt statement of opinion from members using the service would be a great help. (*See page 157*)

◆

MERCURY-ARC rectifiers, gradually gaining a position of importance in the power supply field, have been applied successfully in the strenuous service of subway transit lines. Howard M. Van Gelder, electrical engineer of the City Transit Department, Philadelphia, presents an interesting discussion of the application of mercury-arc equipment on that city's new subway system. Mr. Van Gelder has been more or less intimately associated with electric railway work for more than thirty years, dating back to the initial elevated railway electrification in New York City. (*See page 97*)

Electric Power *in the* Lumber Industry

From logging to the manufacture of finished products the lumber industry depends upon electric power, frequently manufacturing its own from sawmill refuse. The changing order of affairs both inside and outside of the industry now emphasizes fuel economy, places an increasing premium upon wood-waste, and makes by-product electric energy an important revenue producer.

By A. H. Onstad

Weyerhaeuser Timber Company
Tacoma, Washington

ADVANTAGES accruing from the use of electric energy for the distribution of power and for electric drive around a lumber manufacturing plant are many indeed. Prior to the adoption of electric power transmission a lumber plant had at least two, (and sometimes more) complete power plants on its premises, each with a full complement of boilers, engines, pumps, and other equipment as well as a full operating force. One of these plants served the sawmill, one served the planing mill, and sometimes one served a box factory or other side line; or some power user that could not be reached by belt or rope drive from the main sawmill power plant.

Development of the low-pressure and mixed-pressure turbine generators stimulated the early adoption of electric power distribution. With a mixed-pressure machine installed in the sawmill power house to take exhaust steam from the sawmill engine (which usually was a Corliss engine) and to take all the steam from the many steam cylinders throughout the mill, enough power could be generated to serve the planing mill and other departments without drawing much live steam from the boilers. The cost of such electric generating equipment, plus the cost of the electric drives in the planing mill, frequently exceeded the cost of a separate power plant to serve the planing mill; but the investment was justified by the reduction in operating force and in maintenance cost.

Considered only from the angle of fuel economy, electric power as applied to the lumber industry, except in a few isolated instances, had no advantage over any other power until within the last decade. The lumber industry has had such a superabundance of natural fuel in the wood waste from its operation, that loggers have been careful to send to the mill only such logs as would produce a high percentage of merchantable lumber. Under normal conditions the sawdust produced from the lumber cutting and finishing machines is enough, and often more than enough, to serve local power needs. Any additional wood waste at the mill must be burned in refuse burners, which are expensive to build and maintain, and which usually scatter partly burned particles of wood over a wide area with attendant evils.

Gradually, however, because of various changing of incidental conditions, the economic situation with regard to fuel in the lumber industry is changing; wood waste is being used more and more in the production of various "composition boards." Changes made in the method of lumber milling are increasing steadily the kilowatt-hour consumption per unit of lumber, which is reaching as much as 121 kw-hr. per 1,000 board-ft. in some mills that are carrying the manufacturing to a fine degree. This change also is increasing demand for process steam.

These and other changes along with the possibility of selling surplus power to public utilities or other power consumers are placing an ever-mounting value on mill refuse; hence, instead of wood refuse being the traditional liability around mills, at many plants it now has an appreciative monetary value. With a contract for the sale of surplus power, a milling company can run its generating equipment practically at 100 per cent load factor; and if it has sufficient electric generating equipment it can turn all of its mill waste into revenue. Thus it has become imperative that efficient power plant equipment for the conversion of waste products into power be installed within the lumber industry. Motor applications also are being made with ever increasing emphasis upon power conservation in addition to the continuing demand for continuity of service.

One noteworthy example is the recently completed steam-electric generating plant of the Weyerhaeuser Timber Co. at Longview, Wash. In this plant the electric generating equipment consists of two 7,500-kw., 0.8-power factor, 2.3-kv., three-phase, 60-cycle turbine-generator units. Steam is delivered to these units at 300-lb. gage pressure at the throttle and 580-deg. fahr. With the units operating at full load, 150,000-lb. of steam per hr. at a pressure of 125-lb. gage may be bled from each machine for use in the lumber drying kilns.

Two 500-kw., 250-volt, d-c. generators driven by

Presented at A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930. (No. 30-183.)

Two-speed double-motor (synchronous) band-mill drive with associated automatic-control apparatus; 400-hp., 600-rev. per min. and 250-hp., 514-rev. per min.

synchronous motors supply current for 27 cranes used for handling lumber, as well as direct current for other d-c. motors and for the exciting current for the synchronous motors.

Some 1,200 motors, not including motor-driven tools such as portable drills and grinders, motor-driven electrical welding sets, electric clocks, and motor-driven office appliances, aggregate 23,849 hp. These include:

71	2,200-volt synchronous motors	10,645 hp.
30	2,300-volt induction motors	2,875 hp.
1,021	550-volt induction motors	8,575 hp.
78	220-volt direct-current motors	1,754 hp.

The load on this power plant with its 23,849 connected hp. averages 7,000 kw. and by the use of synchronous motors the power factor of the load is kept at 0.96 leading.

In the woods, electric power is now being used in a limited way for driving portable saws for falling trees and bucking them into long lengths. These saws are chains with cutter teeth attached to one side of the links which run over two sprockets, one mounted at each end of the light steel frame holding the sprockets in position and forming a guide for the saw chain. A specially designed motor of about 5-hp. capacity geared to the driver sprocket furnishes the power, taking its energy from nearby transmission lines, or from small gas-driven generator sets which may supply power to several such saws working within a limited area.

Electric power also is being used in a limited way for "yarding and loading" logs. This is the operation of dragging the log from where it was cut out of the tree and loading it aboard the cars for shipment to the mill.

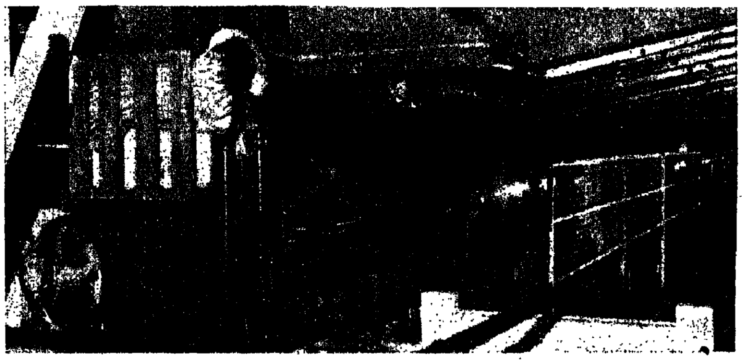
Equipment in use varies for various sections or growth of timber; on the Pacific slope of the Cascade Mountains where it is used to the greater extent, the equipment resembles heavy-duty hoisting equipment both in mechanical construction and in load characteristics.

The yarder is that part of the equipment that is used for dragging the log from the point where it has been cut out of the tree to the railroad siding for loading onto cars. Two full-load line speeds are provided, a high speed being 1,800 ft. per min. and the low speed being 900 ft. per min. The higher speed is used on the smaller logs and the lower speed for the heavier logs. This variation of speed is obtained through reduction gears of different ratios connected to the drum by friction clutches. The usual equipment is a 300-hp. wound-rotor motor having a wide range of speed control through secondary resistance. These motors are designed for a pull-out torque of approximately 300 per cent, but their service is such that frequently they are loaded to the stalling point.

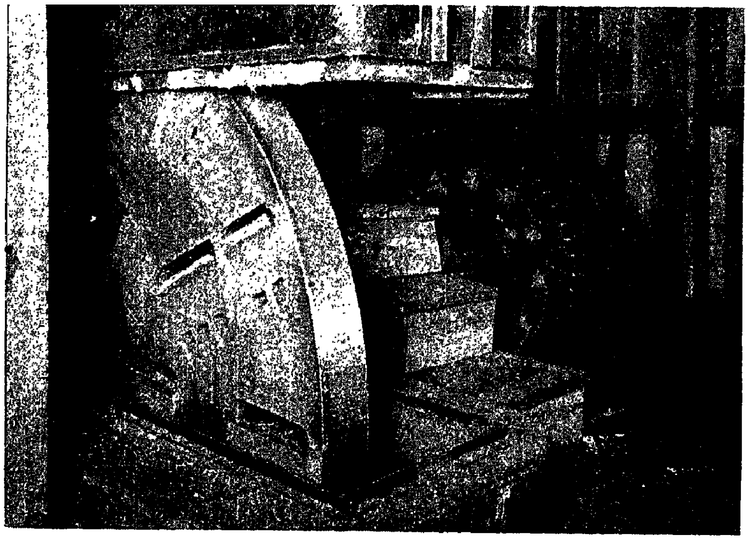
The loading end of this logging equipment usually consists of two 75- or 100-hp. wound-rotor motors. The hoisting line of the loading equipment passes through sheaves properly supported over the load. The usual procedure in loading a log is to fasten one hoisting line to each end of a log; the log can then be manipulated through these double hoists so that one end may be lowered onto the car ahead of the other to conform to the requirements of binding the logs into the load in such a way that they will arrive safely at their destination at the mill pond.

For a large operation on which load factor or days of operation per year is high, and in which life of operation is sufficiently long to permit of reasonable obsolescence charges, this has proved profitable.

One serious disadvantage to the use of electrical equipment for woods operation is the danger of loss of equipment by fire. The cost of electrical logging equipment is so great that the units are built only on order. The time required to replace a machine or repair one damaged by fire is therefore so great that it results in too severe a loss of production to warrant the adoption of electric power for logging operations except in a few special cases. Electric power for the propulsion of trains hauling logs out of the woods is being used in one or two instances, but insufficient tonnage on the average logging railroad prevents its general adoption even for this purpose.



A 250-hp. slip-ring motor driving a gang of trimmer saws



A typical 90-in. "hog" driven by a 400-hp. 600-rev. per min. synchronous motor. This machine reduces slabs and edgings to a refuse suitable for use in the furnaces

There is no specific rule governing the application of motor drive to sawmill machinery; power required for driving the various sections can be computed using the same laws that govern the application of electric drive to any other line of machinery. Before attempting to compute the motor requirements for these applications, however, one making these computations should be thoroughly familiar with the possible loading of the various sections to be driven. In applying motor drive to live rolls and transfer chains, the matter of obtaining sufficient starting torque is usually of prime consideration. The length of the roll trains and transfer tables is so short that if they are left in operation for a period of a minute or two they will completely unload all material that is on them.

Full-voltage across-the-line starters are used for all except wound-rotor and d-c. motors.

Selecting the proper starting equipment requires considerable thought, for with the frequent starting and stopping of the various sections, the duty imposed on the starting equipment is even more severe than that imposed on the motors. Maintenance men spend more time keeping the starting equipment in good operating condition than they do on the motors themselves.

There are many applications where thermal overload relays will not function if the doors of the cabinets enclosing the starting panels are left closed; this is due to the rise in temperature within the cabinets caused by the arc created in opening the motor circuit. Some of the transfer tables in the mill are started on an average of four or five times per minute.

One of the advantages of motor drive is the ease with which the machinery can be started and stopped, which permits running the machinery only through the period that it is actually engaged in moving lumber. As this in many cases is only a small fraction of the total working time of the shifts, considerable wear and tear of the machinery is prevented by stopping its movement when not actually needed.

Among recent applications of starting equipment that has proved worth while is the automatic starting and stopping trains of live rolls and transfer chains to permit the movement of lumber over them; for instance, a train of several sections of live rolls may be used for carrying timbers to the timber dock. As these timbers do not come with any degree of regularity, the rolls need operate only a small portion of the time, with a trip-pan arrangement placed between successive rolls throughout the length of the route. These trip-pans are mechanically connected to the starting stations of the motors driving the sections in such a manner that when the pan is depressed by the timber going over it, the motor is started and kept in operation until all of the pans in that train of rolls are free to rise to the "up" position. With such an arrangement each section of rolls is started as the timber approaches and automatically stops when the timber passes.

Adapting individual motor drive to the machinery of a lumber plant presents many perplexing problems; with few exceptions, the speed of the final drive of sawmill and wood-working machinery can be placed in two groups—a slow-speed group and a high-speed group.

Log hauls, transfer tables, and conveyors belong to the slow-speed group, with final speeds ranging from 1½ to 25 rev. per min. Live-roll drives ranging from 100 to 175 rev. per min. also can be placed in this class.

It was not until the so-called herringbone-type gear was developed and it became practical to build speed-reducing power transmissions of large reduction ratios that individual motor drive for these slow-speed groups became practical and economical. Now, reduction ratios of 150:1 with high efficiency may be obtained. This permits the use of motors of 1,200 to 1,800 rev. per min. to be used for practically every slow-speed drive, resulting in better electrical load characteristics and greater economy of installation.

Cutting speed for saws and the knife-type cutters of wood-working machines range from 8,000 to 14,000 ft. per min., which calls for speeds ranging from 300 to 7,200 rev. per min. These can be classed as high-speed drives. Mechanical connection between these and motors of economical speed characteristics did not present the difficult problems involved in the slow-speed drives.

Recent developments in planing mill machinery such as matchers, moulders, and saws, have opened a new field for the use of high-speed direct-connected motors. A large modern matcher has eight motors, totaling 270 hp., built into the machine. For these applications the machine manufacturers buy the rotor without a shaft and the stator without a frame and incorporate them in the construction of the machines. A modern matcher (commonly called a planer) has the following motors:

Service	No. Motors	Horsepower	Speed (r. p. m.)
Top cylinder	Two	40	3,600
Bottom cylinder	One	40	3,600
Outside side head	One	30	3,600
Inside side head	One	25	3,600
Top profiler	One	30	3,600
Bottom profiler	One	25	3,600
Feed work	One	40	1,200

As the cutter-head cylinders all turn in ball-bearings and are carefully balanced and heavy, they will continue to run for ten or fifteen minutes after the current has been cut off the motors. To make it possible to stop these quickly, the control is equipped for plugging service so that when it is necessary to stop a head or cylinder for any purpose the motor is plugged, bringing it to a stop in a few seconds.

Modern moulders are built for variable speeds of the spindle obtained by varying the frequency of the circuit by the use of frequency changers. For normal work the cylinders are equipped with six or eight knife cutters and usually operate at 3,450 rev. per min. For the exposed surfaces of the moulding requiring a finer finish the particular heads used for this exposed surface are speeded up (by changing the frequency) to 6,000 or 7,200 rev. per min. Control equipment is so arranged that the speed of any one or all of the five cutter heads or cylinders of the moulder may be increased.

Synchronous motors range in size from 50 hp. to 400 hp. and in speed from 225 to 1,800 rev. per min. Two types of loads are selected for synchronous-motor drive; (1) widely fluctuating loads having a low load factor, such as bandmills, edgers, slasher, trimmers and hogs; and (2) large loads of high load factors such as fans, pumps, and air compressors. Synchronous motors are not used on drives that require frequent starting.

All synchronous motors are wound for 0.8 factor and have a pull-in torque of 100 per cent of full-load torque. All synchronous motors are started with automatic, full-voltage, across-the-line starters and with few exceptions are all excited from the 250-volt buses or feeders that supply power to the cranes and other d-c. motors throughout the plant. Synchronous motors located so far from the d-c. lines that the cost of a d-c. circuit to the motor for excitation would be nearly as much as an exciter are equipped with direct-connected exciters.

Synchronous motors have proved very satisfactory for widely fluctuating loads, the application to driving "hogs" being a striking example. Motors of 250 hp. at 600 and 720 rev. per min. and 400 hp. at 600 rev. per min. are used for this, and have field control relays so adjusted that when the motor pulls out of step because of overload, the field excitation is cut out, and automatically restored when the motor again approaches synchronous speed. This may occur as many as 100 times during an eight-hour shift.

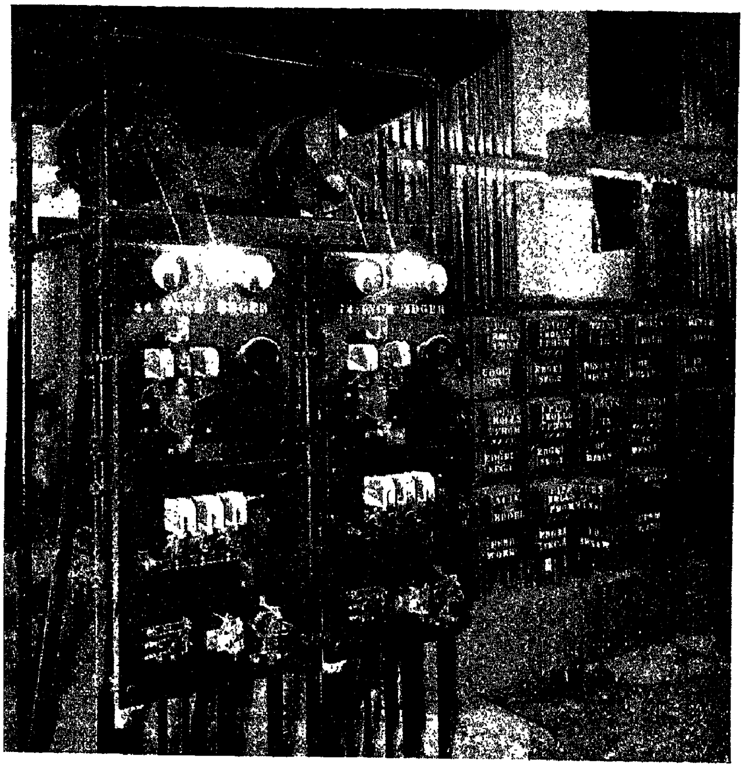
The 2,300-volt induction motors range in size from 50 to 250 hp. These are mostly wound-rotor motors driving machinery requiring frequent starting, or machinery which will not permit the severe strains imposed on it by full-voltage across-the-line starting. Some equipment requires limited speed control and for this purpose the wound-rotor motor and drum controller are both used. Induction motors of 50 hp. and smaller ratings are wound for 550 volts.

Except in sizes of 7½ hp. and smaller, the 550-volt induction motors are of the so-called double-wound-rotor type. These have the starting characteristics of the high-resistance-rotor motor and the running characteristics of the squirrel-cage motors.

One unusual motor application is that employed for driving the main bandsaw. For the regular run of fir logs a saw speed of 10,500 ft. per min. is the ideal speed; but for a certain species of fir log a saw speed of 8,000 ft. per min. is the most practical. As the logs requiring slow-speed sawing are mixed promiscuously with the softer logs, the custom has been to saw them all with the higher-speed saw. This has resulted in erratic sawing of the hard logs. At the Longview mill practically instantaneous speed changes from 10,500 to 8,400 ft. per min. are arranged for. This was accomplished by putting two synchronous motors on one motor base, driving the same pulley with the shafts rigidly coupled together. A 400-hp. 600-rev. per min. motor was installed as the main motor to use in starting the bandmill and for sawing the average run of logs. The other motor was a 250-hp. 450-rev. per min. motor. While the large motor is used for furnishing the power the small motor is disconnected from the line so that the only power required to drive it is that necessary to overcome windage losses. When a hard log is sawn the sawyer, by pressing two push-buttons, disconnects the large motor from the line and connects the small motor, which drops the speed of the saw to 8,400 ft. per min. The change from one speed to the other is made as frequently as the sawyer deems necessary.

Another unusual application of electrical power t sawmill machinery is in driving the feed works of the larger edgers, the machines that rip the boards and timbers into the desired widths. The edger arbor on which the saws are mounted is direct-connected to a 400-hp., 0.8-power factor, 1,200-rev. per min. synchronous motor. The feed rolls that feed the stock into

A modern high-speed planter; 9 of its 13 motors, varying from 2 to 75 hp., are shown



Typical arrangement of starting panels; automatic across-the-line synchronous-motor starters in the foreground

the edger are driven by a 10-hp. series motor through reduction gears and chain drive. These are so proportioned that with no load on the motors the surface speed of the rolls will pull the lumber into the edger as rapidly as good work can be done with the saws. As larger and thicker pieces are sent through the edger the load on the feed works motor increases and automatically slows the feed. Speed characteristics of the 10-hp. motor are such as to provide automatically the proper rate of feed into the saws for the varying thickness of material being sawn.

Among unusual applications of electric power to sawmill machinery is that used by the Weyerhaeuser Timber Company at Mill "C," Everett, Washington. This mill, located approximately three-quarters of a mile away from the power plant, is equipped with individual motor drive throughout, but differs from the usual mill in the respect that no steam is used in the mill for any purpose. The cost of a well-constructed steam line was such that it was decided to use compressed air in place of steam for operating all lifting cylinders, loaders, niggers, etc. A two-stage air compressor, having a capacity of 1,500 cu. ft. of free air per min., driven by a 250-hp. synchronous motor, furnishes all of this compressed air.

For driving the sawmill carriage a slow-speed, d-c., traction-type elevator motor was used, specifications calling for a torque of 12,500 lb. rather than the conventional horsepower rating. Power for this motor is taken from a motor-generator set consisting of a 75-hp., three-phase motor driving two d-c. generators; one to furnish current to the armature of the motor and a smaller one to furnish current for exciting the fields of the generator and the motor. Accurate and quick speed control of the carriage is achieved through a Ward Leonard system which has proved highly satisfactory in every respect.

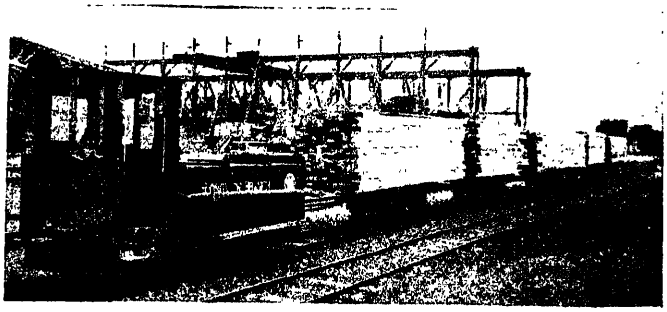
Armature leads of the motor are connected directly to the armature terminals of the generator, with the full field left on the motor at all times. Hence, speed control is effected by varying the voltage of the generator through field resistance placed in the field circuit of the generator. Reversal of the motor is effected by reversing the fields of the generator. This motor is connected to the carriage through wire ropes, one end of which is securely fastened to the carriage, the other end being fastened to a 30-in. sheave on the motor shaft. The cycle of operation is two revolutions in one direction and then two revolutions in the opposite direction, at a normal rate of from seven to thirteen cycles per min. Because the motor does not set up any windage through the coils by its own revolutions, it was necessary to provide artificial ventilation. This was accomplished by enclosing the motor in a galvanized iron housing through which cool air is forced by a motor-driven fan.

The most recent application found for electricity in the sawmill industry incorporates a Taglibue-Heppenstal moisture indicator. This consists of a case in which is mounted a battery, amplifying tubes and transformers, and an ammeter. Long, flexible leads from this cabinet are connected to two sharp terminals in a small portable handle that the lumber tester carries with him when inspecting lumber. When the points are driven into a piece of wood a current is set up and the value of this current is calibrated as the percentage moisture content of the wood. This method of testing

A double-squirrel-cage, 7.5-hp., 1,200-rev. per min., 550-volt induction motor direct-connected to conveyor drive for "dryness of lumber" has proved so dependable that it now is a standard for testing lumber that is bought with specification calling for a definite moisture content.

Storage-battery locomotives usually of seven-ton capacity having 225-ampere-hour batteries are used for the transportation of lumber from one department to another, where these departments are so arranged that transportation cannot be readily accomplished by crane service. These locomotives run on a 30-in. track, pulling four-wheel roller-bearing industrial cars with train loads as great as 60 tons. They stay in service for eight-hour shifts without recharging of the battery. Small storage-battery trucks and lift trucks are used in some departments for stacking certain items of lumber and for short-distance movement of lumber.

With modern industrial lighting units it is possible to provide illumination so suited to the work that production can be carried on at night with as high a rate of efficiency as that obtained during daylight operation.



A 7-ton battery locomotive in mill yard service

Power required in kilowatt-hours per 1,000 ft. of lumber sawed varies over a wide range, depending upon the sizes of the finished product and the completeness with which the manufacture is carried on.

At a large recently constructed fir mill the power required amounts to 34 kw-hr. per 1,000 ft. of lumber through the mill when sawing the sizes commonly encountered in ordinary construction. The total power consumption of the mill in question amounts to 80 kw-hr. per 1,000 ft. of lumber, including the power required for sawing, for fans at the dry kiln, for planing, and for transportation.

Another large plant handling both pine and fir and producing lumber of various standard sizes shows an over-all power consumption of 78.5 kw-hr. per 1,000 ft. of lumber produced divided as follows:

TOTAL KW-HR. PER 1,000 FT.

Sawmill	26.6
Planing mill	14.9
Dry kilns	24.5
Lighting and transportation	12.5
Total	78.5

Mercury Rectifiers for Subway Service

Simplification in station design, construction, and operation results from use of mercury arc rectifiers and metal-clad switchgear and bus units; ventilation and noise problems easier to cope with; 9,000-ampere load swings handled by single unit.

By H. M. Van Gelder
Electrical Engineer,
Department of City Transit,
Philadelphia
Member A. I. E. E.

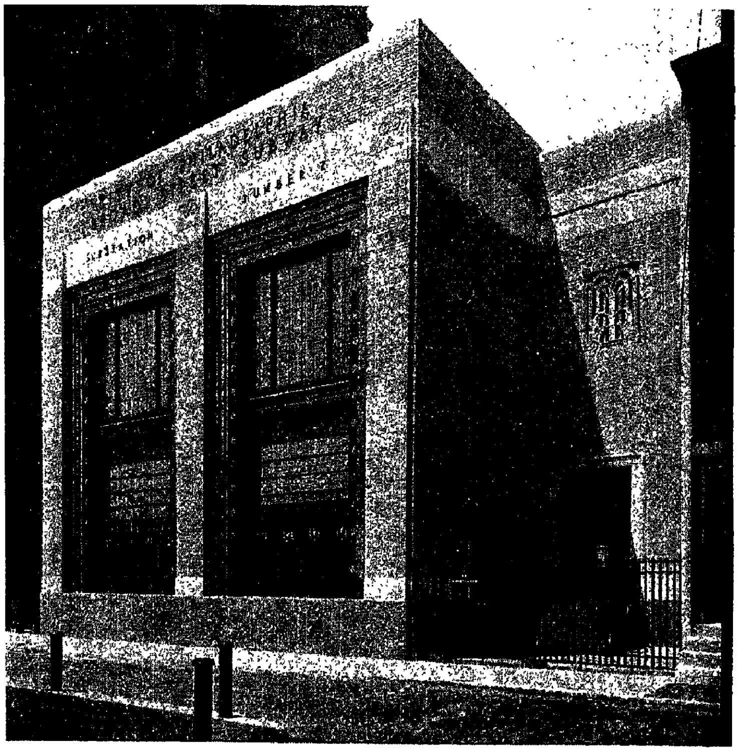
DEPARTING from previously established practise, the Philadelphia Department of City Transit has installed in its most recent substation, mercury arc rectifiers instead of the synchronous converters as installed at its other three substations. This change in equipment selection was brought about partly by recent improvements and developments in rectifier equipment, and partly because some difficulty had been experienced with the synchronous converters flashing over with extreme load variations. Other influencing factors included the better efficiency of the rectifier at light loads, the absence of large rotating parts with their attendant troubles and noise, the absence of commutation of heavy current, better stability under short-circuit conditions, and the relative simplicity of bringing them on the line for service.

Initial construction of Philadelphia's Broad Street subway was started in 1924 and the first six-mile section extending northward from the City Hall was placed in operation in 1928. Initial construction will accommodate four tracks, but at present only two local tracks are installed and in service. To serve this first section, three 6,000-kw., synchronous-converter substations (each containing two 3,000-kw. units—one as a spare) were built at convenient points and of sufficient size to accommodate equipment to serve the expected ultimate subway development.

An extension of the Broad Street subway south from the City Hall, a distance of about three-quarters of a mile, necessitated the construction of a fourth substation to serve an immediate demand for traction power and to serve as a basis for further extension. Experience obtained through two years' operation of the six-mile North Broad Street unit of the subway, indi-

---

From "Substations of the Broad Street Subway of Philadelphia," (No. 30-173) presented at the A. I. E. E. Middle Eastern District meeting, Philadelphia, Oct. 13-15, 1930.



Substation architectural treatment is in keeping with surroundings

cated by short-time peak loads, would determine the capacity of rectifier units and that such peaks usually lasted less than ten seconds, or during the multiple motor operation on notching acceleration. Consequently the 300 per cent load rating was reduced from a three-minute limit to a one-minute limit, and a unit having a continuous rating of 4,000 amperes at 630 volts, 6,000 amperes at 612 volts for two hours, and 12,000 amperes at 550 volts for one minute, was decided upon. Two units have been installed, one to serve as a spare. The present building will accommodate four units.

Regulation of these rectifiers closely approximates that of the synchronous converters in the original substations, thus making it possible for the two types of substations to be operated in parallel even for extreme fluctuations of load. It is not intended to install both converters and rectifiers in one substation for parallel operation; and there is no necessity for it.

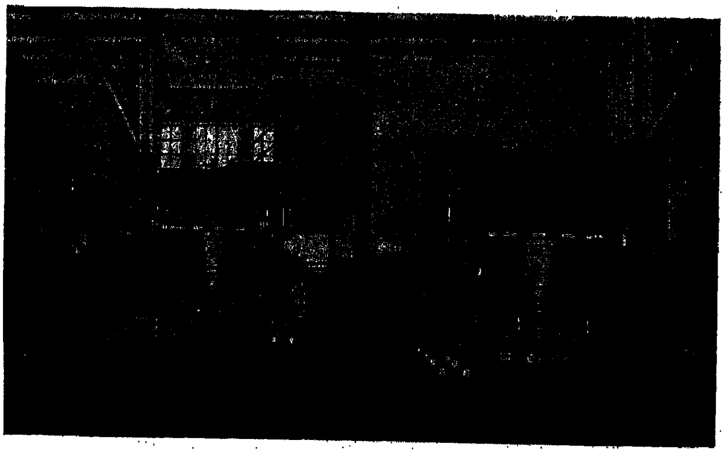
Rectifiers are water-cooled, double six-phase units, containing 12 anodes and equipped with automatic a-c. ignition and excitation, automatic water control, and an indicating vacuum regulator which controls the rotary pump according to predetermined vacuum points. This vacuum regulator also removes the rectifier from service if the vacuum falls before a predetermined value. Thermometers with electrical contacts provide the necessary thermal protection for each rectifier unit. Serving each unit there is a static mercury vacuum pump and two rotary oil vacuum pumps, one of which is a spare. The spare pump was specified as an extra precaution against possible failure of the one piece of rotating apparatus involved in the substation. Operating experience has shown that this rotary pump operates not more than 25 per cent of the time under present conditions.

The only cooling water required for the substation is for the rectifiers and the supply for this service is taken from two different city mains to insure availability of continuous supply. Because of the relatively light continuous load and the prevailing low cost of water, it has been found to be cheaper to waste the water than to provide cooling equipment for its re-circulation.

Transformer cells or rooms are provided at each of the four corners of the building, an arrangement which permits each transformer cell to have two outside openings at ground level and a large individual ventilator in the roof. One of the ground-level openings contains adjustable louvers and the other has a vertical lift door which gives entrance from the street; thus natural ventilation from two directions is provided. Since noise is practically completely absent from the equipment of this substation, no special precautions had to be observed in connection with sound-proofing and no special ventilating problems were involved.

Another departure in design in this substation was the use of an armor-clad bus and switchgear structure affording complete circuit accommodation for the incoming 13.8-kv. circuits, bus, oil circuit breakers, instrument transformers, disconnecting devices, etc. All cable leads to and from the armor-clad structure are lead-covered and wiped permanently to potheads which form a part of the structure itself. One attractive feature of this type of equipment is that all relays and connections are self-contained and mounted on the various switchgear units. Also, each armor-clad structure is completely built and assembled in the factory, requiring no masonry structure in the station except for foundation blocks; this simplifies both station design and station construction.

The subway d-c. power demand is of such a fluctuating character and, at present, has such a low sustained value that it was found of little use in forming or baking-



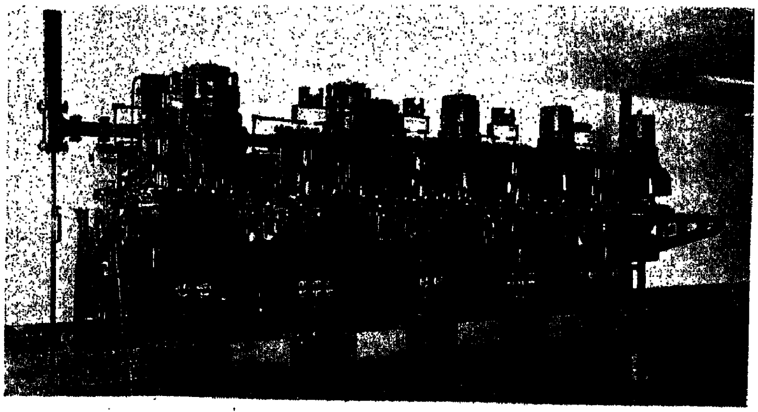
Two 4,000/12,000-ampere rectifiers in subway service; one a spare out the rectifier. To furnish a continuous load for this purpose a water rheostat which will absorb 1,200 amperes has been installed to operate in parallel with the traction load. If necessary, the rectifier can be operated six-phase or three-phase at times of bake-out to increase the current per anode.

All apparatus in the substation is controlled from the main switchboard in an operating office on the rectifier floor. All other switchboards and all 630-volt d-c. circuits are in the basement. The d-c. connections from the cathode of the rectifier pass directly through the floor to the rectifier switchboard below. This board contains a remote-control positive switch and a special quick-acting circuit breaker for each rectifier, with auxiliary switches and interlock so arranged that when the 13.8-kv. oil circuit breaker of the rectifier unit is closed, all other starting functions are performed automatically. Thus the operator has only to close the positive d-c. circuit breaker control switch to bring the rectifier on the bus.

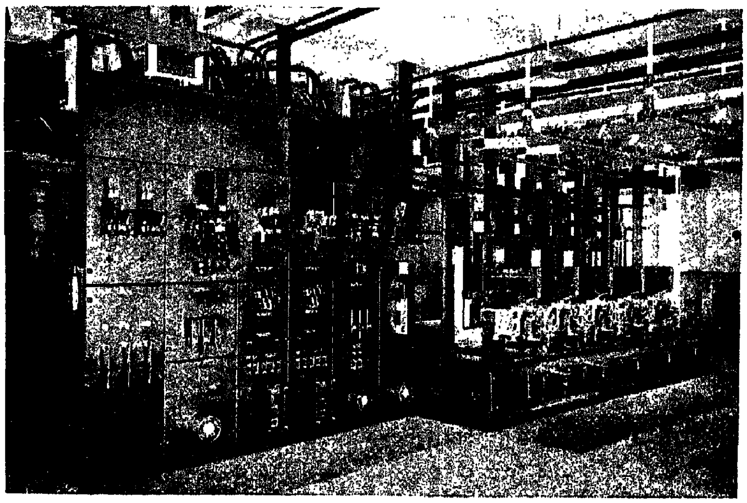
The four neutral connections of each main transformer are carried to the basement through wall ducts to its interphase transformer located immediately adjacent to the negative bus. The neutral lead of this interphase transformer constitutes the negative connection of the rectifier nuit and is connected to the negative bus.

From the rectifier switchboard in the basement the main 630-volt positive circuit runs directly to the positive bus; thence through the high-speed circuit breakers to the feeder switchboard and out through underground cables and conduits to the air circuit breakers and contact rail in the subway. Thus, all 630-volt power circuits are kept off the main floor. Furthermore, all of these circuits are run in the basement by means of copper bars, no cable being used until the outgoing underground cables are reached.

The station auxiliary switchboard in the basement has its principal operating circuits controlled from the main control board in the operating office. A 125-volt storage battery supplies energy for the control circuits while the auxiliary a-c. circuits for the rectifier units have three separate sources of power to insure continuity of service—an auxiliary station transformer fed from the 13.8-kv. main bus, and a second auxiliary transformer fed from either of two 4.6-kv. lighting feeders brought into the station from different power sources.



Metal-clad switchgear units simplify construction, operation, and maintenance



Rectifier switchboard and high-speed breakers in Philadelphia substation

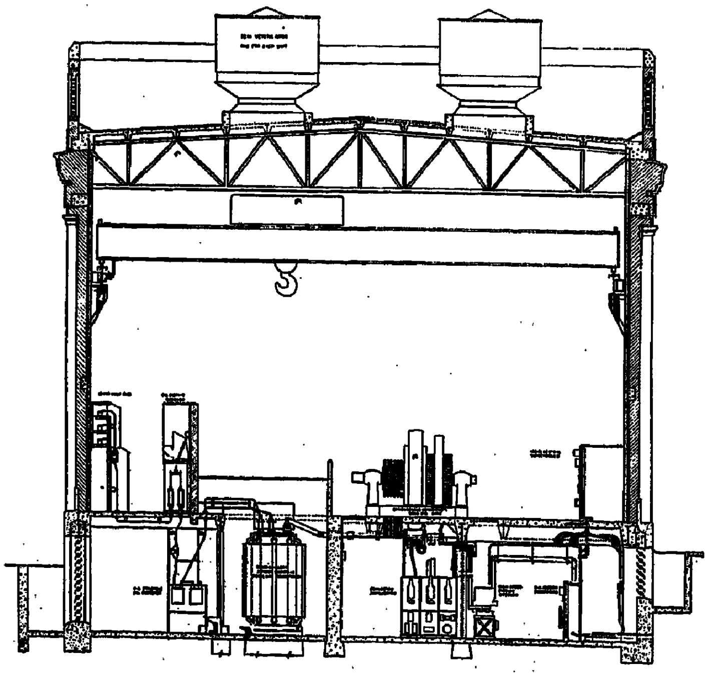
Since it was placed in operation April 20, 1930, this heavy-duty rectifier installation has functioned satisfactorily. During early operation a few back-fires occurred doubtlessly due to insufficient baking-out of the rectifier before heavy overloads were carried. However, no damage was done and now loads of 10,000 amperes are taken by one rectifier unit. There has been no signal or telephone interference experienced as the result of the operation of this substation. Telephone circuits in the district are carried in underground cables.

Since the converter stations also are relatively new and represent current practise a brief outline of their equipment and operating characteristics may be of some interest. At present there are installed in each of these original substations duplicate compound-wound 360-rev. per min. 60-cycle converters, which were characterized at the time of their installation as being the largest that had been built for 630-volt traction loads. The actual rating of each machine was 3,000 kw. at 630 volts for continuous duty when supplied with six-phase 60-cycle power at 100 per cent power factor; 4,500 kw. at 630 volts for two hours, and 6,000 kw. at 560 volts for three minutes.

The starting and control system for these converters has some unique features; it was designed for star-delta starting by the automatic switching of the high-voltage windings of the transformers; for assuring correct polarity; to avoid error in brush position; and to prevent closing a dead machine onto the bus. The sequence of operations when starting the converter is as follows: To insure correct polarity, the field is excited from the control-battery circuit before the main oil circuit breaker can be closed by the control switch. The closing of the oil circuit breaker completes the closing circuit of the star oil switch, if the brushes on the converter are raised. When the converter has attained synchronous speed a relay bridges a gap in the tripping circuit of the star oil switch, and this circuit is completed by another relay which closes at a definite value of the field current after the field switch has been thrown over to self-excitation. The star oil switch on opening completes the closing circuit of the delta oil switch, provided the oil circuit breaker continues closed. The oil circuit breaker is trip-free during these operations so that full protection is assured. The d-c. switches and circuit breakers are electrically operated, but before the positive switch can be closed the delta oil switch must be closed, brushes lowered, equalizer switch closed, and positive circuit breaker closed.

The oil circuit breaker will open on over-current or low voltage and, by interlock control, automatically opens either the star or delta oil switch and the d-c. circuit breaker. The d-c. breaker opens on over current, reverse current, over speed, or under voltage, and upon opening, opens the positive switch and the equalizer switch.

In the event of a converter flashover, a ground relay opens both the oil circuit breaker and the d-c. breaker; thus it may be seen that many of the operations are automatic, the operator performing only the initial movement of a sequence. The design also assures speed of operation and prevents an operator from making mistakes in putting a converter on the line. At the time of an unexpected failure of the power supply to a substation, the operator was able to clear all feeder circuits and auxiliaries, ordered power on again, started up the station, and established full d-c. feeder service in three minutes.



Section through a converter substation where ventilation and sound-proofing must both be assured

These three substations have been in operation for over two years and all equipment has functioned very satisfactorily. The converters have flashed over occasionally but have not averaged more than two or three per year per machine; and when they do occur, the damage is slight and usually the machine does not have to be left out of service. The flashovers generally occur at times when a heavy load is suddenly cut off, particularly where a limited short circuit occurs which does not open the high-speed breaker but clears itself or is cleared by a subway air circuit breaker. Apparently the flashovers are due to large synchronizing currents caused by angular displacement of the armature after heavy momentary load.

One operator and a helper are on duty in each station at all times.

◆ ◆ ◆

Electrolysis Survey at Louisville, Ky

Cooperative committee finds that electrical drainage is only a partially effective measure in the protection of pipe systems.

By W. C. White

Southern Bell Tel. & Tel. Co.
Atlanta, Ga.

PREVIOUS to 1926, no concerted action in respect to the electrolysis of underground metallic structures in Louisville had been taken, although the individual action of the water, gas, and electric and railway companies had served to mitigate specific cases of trouble. Realizing that the electrolysis problem could be solved only by securing complete data on all of the underground metallic structures, a conference of the public utility companies was held which resulted in the formation of the Louisville Electrolysis Committee in which all of the public utilities were represented. A citywide electrolysis survey and test procedure were planned the expense of which was prorated among the interested utilities.

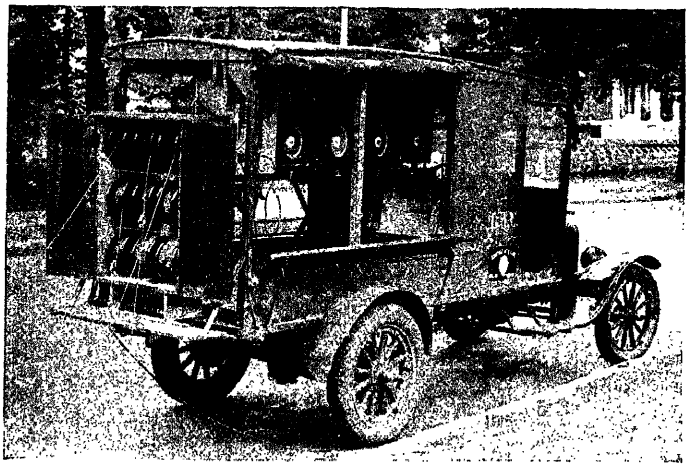
A potential survey was made of the entire city, tests being made at over 600 points. It was found advantageous to use recording meters, and twelve of the smoked chart types were mounted on a truck with suitable switching arrangements for connecting them

---

From "A Cooperative Electrolysis Survey in Louisville, Ky.," presented at A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930. (No. 30-189.)

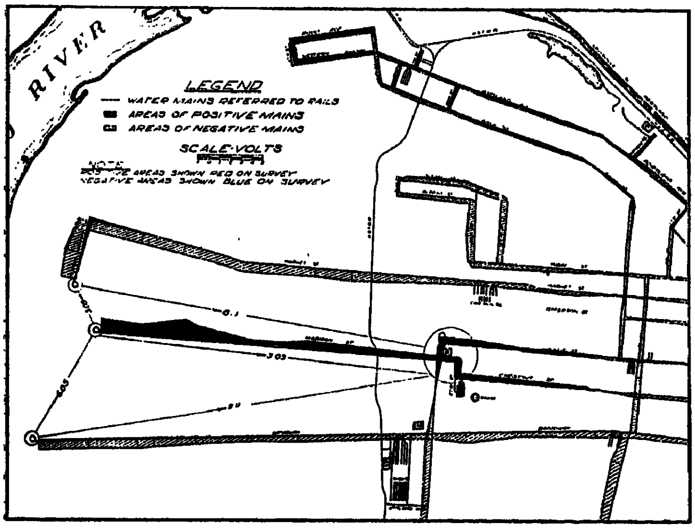
between various structures and between structures and earth.

A current survey of sub-surface structures supplemented the potential survey, in determining probable hazardous conditions and furnished valuable data for consideration in the application of remedial measures.



Specially equipped truck typical of those used in Louisville, Ky., electrolysis survey

A current survey of cable systems is a relatively simple procedure and in a great many cases will indicate hazardous conditions where they would not otherwise be located. Approximately 72 such test stations were established on the underground systems of Louisville and 24-hr. records were made of the stray currents. Numerous measurements were also made of track-potential drop and track-potential gradients.


RIVER
LEGEND
WATER MAINS REFERRED TO RAILS
AREAS OF POSITIVE MAINS
AREAS OF NEGATIVE MAINS
SCALE-VOLTS
NOTE
POSITIVE AREAS SHOWN RED ON SURVEY
NEGATIVE AREAS SHOWN BLUE ON SURVEY

A graphical method of presenting electrolysis survey data for joint study

Soil resistivity tests were made on 180 samples which differed widely, but averaged about 5,000 ohm/cm.

Test data were assembled on cards at the time when current or potential tests were made. A card was prepared giving the number and location of the test point and cross-referenced with the corresponding records. On the reverse side of this card was shown a diagram of the test point and the location of structures to which connections were made. This was done in order that any test could be repeated with identical connections at any time. Those portions of the data capable of graphical presentation were plotted on maps, the areas indicated by the positive potential ordinates being colored red and that of the negative potential ordinates, blue.

When sufficient data were obtained in any section from which definite conclusions could be reached, the electrolysis committee, which met weekly, recommended mitigative measures in order that these might be applied as the survey progressed.

No quantitative results are given, but the success of the methods outlined in improving the general electrolysis conditions in the city has resulted in the continued active existence of the committee which functions as a central clearing house for the investigation of all matters relating to electrolysis in Louisville.

◆ ◆ ◆

Fog-Type Insulators Eliminate Transmission Line Flashovers

ACCORDING to A. C. Nielsen Company, engineers, Chicago, and J. E. Woods and E. T. Ankele, respectively chief engineer and operating engineer for the Central Power & Light Company, San Antonio, Texas, Lapp standard fog-type insulators have been instrumental in solving a troublesome transmission line problem on the power company's 17-mi., 66-kv. transmission line between Sinton and Robstown, Texas. The line in question is subject alternately to dust and salt fogs, and for some time prior to its reinsulation there occurred an average of some ten insulator failures and consequent service interruption. Analysis of maintenance costs showed an average expenditure of of $152.50 annually to cover necessary replacements, and this together with troubles arising from interruptions to important service brought about a reinsulation which was completed about two and one-half years ago. At that time the 66-kv. pin-type units previously in service were replaced each by three No. 5805 fog-type units. It is stated that insulator failures due to arcover have been eliminated entirely.

The line in question is carried on H-frame structures for the most part, using 22-ft. wooden crossarms giving a 10-ft. 6-in. spacing between conductors. Supporting I-bolts of the insulator strings are grounded to a copper strip running along the top of each crossarm and grounded by wires extending down the pole and wrapped around the base of the pole before erection. The line is rated at 15,000 kv-a., 66 kv.

Railroads *versus* Transmission Lines

Double use of railroad right-of-way permits high-voltages transmission lines to penetrate closely built-up area; also effects economies through coordination in railroad electrification and transmission construction.

By W. W. Woodruff and G. I. Wright

Superintendent Aerial Lines
Philadelphia Electric Company
Associate A. I. E. E.

Engineer Electric Traction
Reading Company, Philadelphia
Member A. I. E. E.

Because of a combination of factors, Philadelphia has been obliged to take several steps in the matter of utilizing railroad rights-of-way for electric power transmission purposes and probably has made advance further along these lines than any other city in this country.

While in other localities, the same factors may not be operative with relative importance it is probable that in the immediate vicinity of any large cities there are, or will be, a combination of circumstances which make the utilization of railroad rights-of-way for electric power transmission purposes both essential and expedient.

It is felt that the results obtained in Philadelphia have been highly satisfactory—beneficial to both the railways and the electrical industry; a wider knowledge as to the general features should be of interest to others.

In order to make the situation clear it will be well to review the various factors involved, briefly tracing developments through several stages.

Philadelphia is located on a peninsula formed by the junctions of the Schuylkill and the Delaware Rivers. South of the Schuylkill River there is an industrial development which extends through Chester and Marcus Hook to the State of Delaware. West of the Delaware River there is an urban section of congested development from one to six miles deep, extending for about twenty miles along the water front. Back of this strip is an area of suburban and semi-rural development forming a belt probably some twenty miles deep and extending from the vicinity of Trenton to the Mason-Dixon Line.

The main steam plants of the Philadelphia Electric Company supplying this region with electrical energy are of necessity located along the Delaware River. A glance at a map of the territory indicates that plants along the Schuylkill would be better strategically for feeding this specific territory. However, large stations on this river are impractical because of the fact that the river flow is comparatively small. The oldest station of the Philadelphia Electric Company is located on the Schuylkill and is still in operation, but for a number of years it has not been advisable to add to its generating capacity and it is doubtful if it will ever be expedient to rebuild it. Consequently, a major problem of means to carry power into Schuylkill station has been to establish other strategic points of large capacity supply, and to tie these in with the larger generating stations in the territory and outside sources of supply.

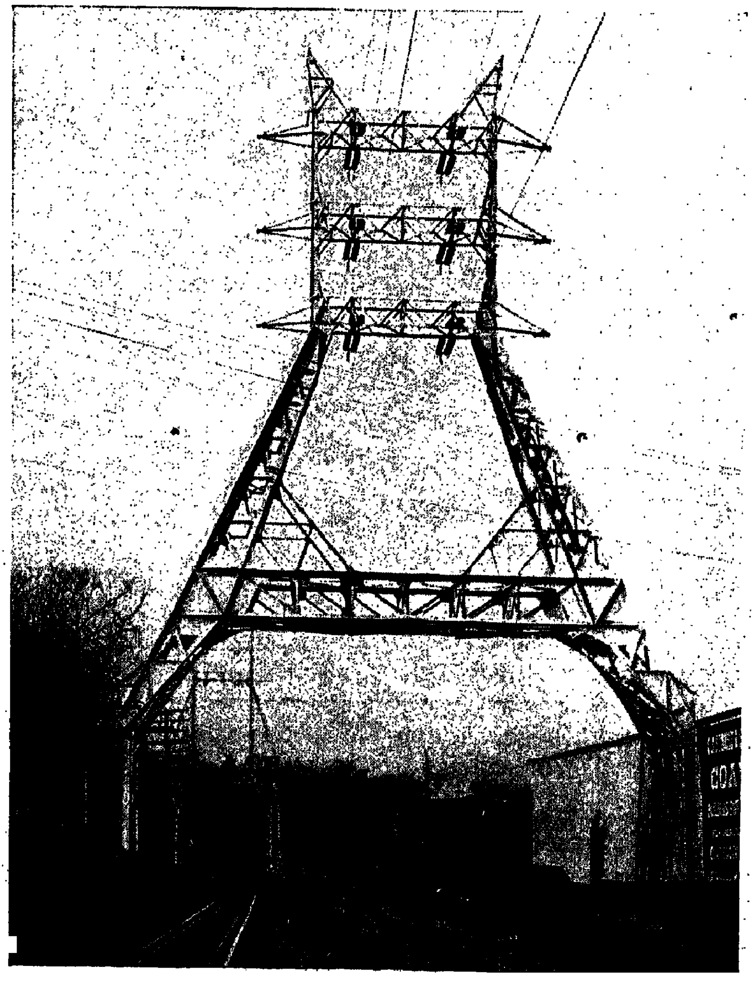


Fig. 1. A 66-kv. four-circuit tower on a restricted right-of-way of the Reading railroad

---

From "Utilization of Railroad Rights-of-way for Electric Power Transmission and Coordination with Railroad Electrification," (No. 30-174) presented at the A. I. E. E. Middle Eastern District meeting, Philadelphia, Oct. 18-15, 1930.

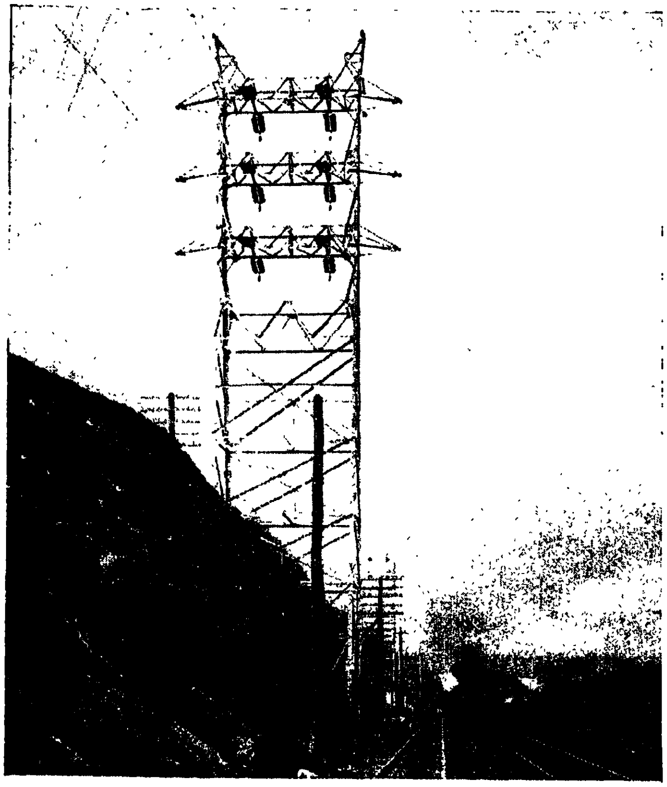


Fig. 2. Four-circuit 66-kv. tower on Reading railroad right-of-way where space is available outside of tracks

In considering the transmission of large blocks of power from outside sources into these urban centers, securing a satisfactory right-of-way to the economic centers of distribution is frequently almost impossible. Through highly developed districts various railroad lines form the only feasible routes. Practically all rights-of-way are railroad property.

The first major problem of this kind in Philadelphia originated about 1915-16, when in order to back up the older station and take advantage of the more economical generation at the newer station it became essential for the electric company to have a 66-kv. transmission line between Schuylkill station in Philadelphia and the new Waterside station in Chester.

The only feasible route between these two stations was along a freight line of the Reading Railroad and a short section of the Pennsylvania Railroad which ran between Philadelphia and Chester. Practically all the property along this railroad route was either already developed or had so much of potential value for future manufacturing sites that its purchase for transmission lines and the securing of a permanent right-of-way over it, were out of the question. Consequently, the transmission line was built largely on the railroad right-of-way. The type of agreement between the companies was one which might naturally be expected in a period when considerable difference of opinion regarding wire crossings, (Pennsylvania General Order No. 13 and other items) existed between the railroads and power companies, and naturally, the agreements had a revocation clause, as was then customary.

A similar situation developed in 1924 in connection with a project of the electric company's for interconnection between Philadelphia and Trenton. The district immediately adjacent to the Richmond Station, from which circuits must run, was so highly developed that the only expedient was to run underground cable for a distance of about four miles and then construct a 66-kv. steel tower transmission line on the Oxford branch of the Pennsylvania Railroad for a distance of about five miles.

The electric company was loath to invest several hundred thousand dollars on a right-of-way where it had no really permanent and irrevocable rights; at the same time, the railroad company was loath to grant any permanent rights on its property owned for transportation purposes. In this case the question was solved by the electric company purchasing in fee simple the additional property outside the line of proposed tracks, which it had been necessary for the railroad company to secure for cutting and filling in road-bed construction. In return the electric company gave to the railroad the right to cross its fee-simple right-of-way to reach adjoining industrial developments wherever necessary, receiving certain rights to maintain wires overhanging the railroad right-of-way.

This agreement was greatly preferable to the revocable type mentioned previously, and was obviously a step forward in cooperation, but could hardly be called complete coordination.

The lines mentioned here were of comparatively small capacity. A much more serious situation developed when it was necessary for the electric company to make plans for bringing into its metropolitan system the Conowingo power output. In this project transmission had to be provided not only for Conowingo power itself but also for power involved in the interconnection between the Philadelphia Electric Company, Public Service Electric and Gas Company of New Jersey, and the Pennsylvania Power & Light Company. Transmission capacity of about 600,000 kw. was required.

Obviously it was necessary to deliver this amount of power well into the highly developed sections of the city at as high a voltage as practicable; and it was equally obvious that it was desirable to bring it in as far as possible on aerial construction. Initially, it was quite evident that a considerable portion of this power must be distributed to the various generating stations in the city by means of 66-kv. underground cable, but on account of the investment, this length of cable must be kept at a minimum.

The only feasible route into the highly developed territory to a point desirable from a distribution

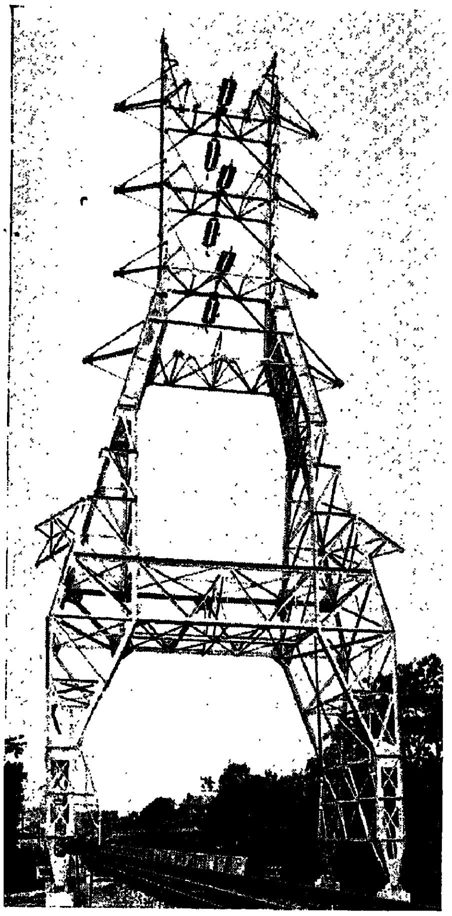


Fig. 3. (Left) Latest type of tower used on restricted Reading right-of-way, providing for three 66-kv. power circuits and four railroad circuits

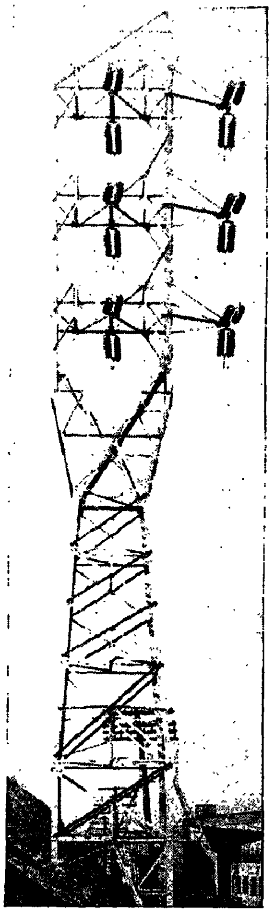


Fig. 4. (Right) Special two-circuit tower for use along side of railroad tracks

standpoint lay along two lines of the Reading Railroad paralleling the Schuylkill River from a point slightly inside the city limits, the latter point being accessible by the conventional aerial construction on private right-of-way.

The situation required an agreement which would be mutually satisfactory to the railroad company and the electric company. Obviously, a project forming so vital a link in so large and important an undertaking must have a permanent status; its continuity must not depend upon any revocable clause or other consideration which did not guarantee permanent and perpetual rights to the electric company. It was equally obvious that the railroad company was in the same situation and must preserve permanent rights for maintaining its operating facilities, as well as the ability to change and increase those facilities as conditions required.

Occupation of railroad right-of-way for electrical transmission can in no wise be considered similar to the utilization of public highways. Due to its prior development the railroad company owns outright and in fee simple the major portion of its right-of-way; consequently, it gives up none of the rights invested in the ownership of property or in any way limits itself in the development of its facilities.

With the Reading Railroad situation, these factors were readily appreciated at the beginning; it was obvious that the conditions required consideration and the finding of a satisfactory solution for—

(a) the designing of the structures of strength adequate to meet severe conditions of climatic loading, and the rules and regulations of any public service body;

(b) designing and locating the structures so that they woudl not interfere with the operation of the railroad company's existing or proposed tracking and facilities;

(c) locating and designing structures to serve as supports without interfering with supports for the future railroad electrification circuits;

(d) in the event of alteration, augmentation, or reconstruction of the railroad facilities, to provide for a joint study of the situation for the most economical means of improvement;

(e) reconstructing or altering the signal and communication system so as to secure satisfactory operation under inductive coordination conditions of future railroad electrification and train control;

(f) the apportionment of costs resulting directly or indirectly from occupation of the railroad company's right-of-way by transmission circuits the electric company's;

(g) the determination of a rental charge for rights of occupation.

The final agreement recognized all these factors. The advantage to the electric company is chiefly a permanent right-of-way through a district precluding independent ownership from either a financial or a public policy point of view. But the electric company assumes a considerable liability.

The benefits to the railroad company are;

(a) the control and coordination of the physical and inductive conflict which might arise were electric lines to be located off the right-of-way but parallel to it;

(b) obtaining supports for its electric transmission and catenary circuits;

(c) the alteration of all signal and telegraph facilities to be unaffected by the operation of the electric company's facilities also safe-guarding railroad electrical operation of trains;

(d) an annual rental charge for occupation of right-of-way.

One important feature should be remembered; were the electric company obliged to purchase a right-of-way, a considerable portion in this case would have either paralleled or been in close proximity to the railroad right-of-way. While the feature of physical interference would have been decreased, the inductive interference situation would have been almost the same as exists with the transmission circuits on the railroad right-of-way.

It is not intended to give here a detailed description of the structural features; they are of greater interest to the structural than the electrical engineer. Only a few points of major interest will be mentioned.

The general electrical features for the electric company's transmission circuits are very much the same as those now used for 66-kv. lines on the conventional steel-tower type construction; that is, the vertical separation between conductors is approximately 10 ft., the minimum clearance to steel work 2½ ft., with the circuits protected by ground wires to avoid lightning disturbances.

In the original installation of about 4½ miles on the main line and Richmond branch of the Reading Railroad, provision was made for four three-phase circuits, it being originally intended that two of these circuits would be reserved for the electric company and the other two positions for the railroad company. (Fig. 1) With the further development of the railroad company's plans it proved feasible to change the formation of the top of the structure so that on the recent Norristown branch construction three three-phase transmission circuits were provided for the electric company and space for two two-wire circuits for the railroad company. (Fig. 3)

To meet the requirements necessitated by future track construction, right-of-way, etc., several expedients in the design of structures were necessary. For the greater part of installation on the main line and Richmond branch, located on a cut on the side of a precipitous slope, there was sufficient room on the side of the cuts and fill to place the structures outside the line of any present or proposed tracks, (Fig. 2); but as the more congested portion of the city was approached, the right-of-way conditions naturally became constricted and in some locations the conditions could be met only by a bridge type of construction which completely spanned a four-track roadway. At other locations it was possible to meet the requirements by dividing the construction, placing the towers on opposite sides of the right-of-way with one circuit going through the center of the structure and the other circuit overhanging the roadway. (Fig. 4)

In the construction on the Norristown branch of the Reading railroad the right-of-way is very much constricted for about the first three miles from termination of the line. Throughout this section it was necessary to utilize the bridge type of construction over a proposed four-track roadway. This roadway involved a project to eliminate a grade crossing and several interesting situations had to be considered.

In certain portions a retaining wall was to be built and the design of foundations for transmission structures must necessarily be coordinated with the design of the retaining wall, the tower footings forming portions of this wall. In another location a steel viaduct was to be constructed so designed at the necessary location that the steel work for the transmission structures could be attached directly.

One circuit of the new construction should now be in operation, service on the initial construction being of something over two and one-half years standing with very satisfactory results.

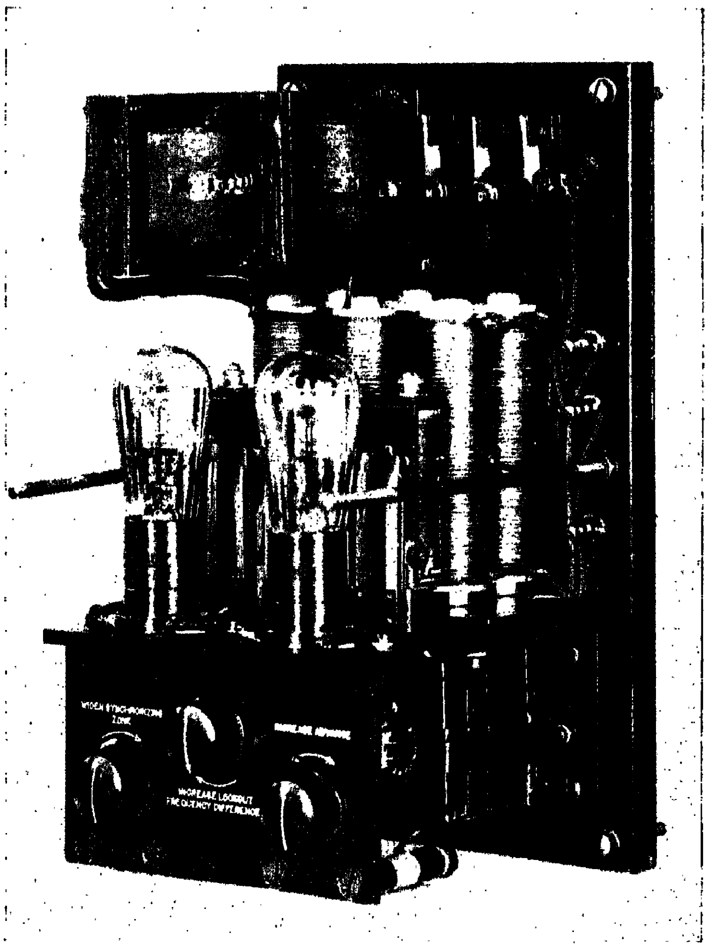
By words of conclusion, transportation of coal from the mines to urban centers, and of electrical energy from hydroelectric supply sources to these same centers, affect all industry and directly or indirectly a large proportion of the whole country's population.

The more intensive the use of rights-of-way for the transportation of these commodities and the successful coordination of the problems involved, the greater the tribute to the managements of the respective companies. Cooperation cannot but result in substantial public benefits.

◆ ◆ ◆

Synchronizing With Vacuum Tubes

THE day's tense moment in the old time power plant came when big machines were synchronized—pilot lights undulating dim and bright, the pointer turning slowly and more slowly; an instant of resolve and the switches slammed in.



No moving parts in this synchronizer

Then either a protecting grunt from the machines, or a sigh of relief from the operator.

All this is gone by, and now even the mechanical synchronizers of recent years may be replaced by a Westinghouse vacuum tube arrangement of 1930 which having no moving parts and demanding but five volt-amperes can draw its energy from a condenser bushing—a substantial advantage over mechanical synchronizers which, requiring 66 to 150 volt-amperes, must be fed from expensive potential transformers. The low power consumption of the new synchronizer is partly due to the use of hipernick in small transformers embodied in it.

The principle of operation involves current based on the beat frequency between the two circuits rectified and used to control the grids of the vacuum tubes. The two simple adjustments are made by radio type rheostats. One changes the frequency difference at which it will synchronize (usually $^1/_6$ cycle); the other adjusts the angle of advance to allow the circuit breaker to close at exact synchronism.

The new synchronizer is twice as accurate as the most skilful human operator, and should last longer if calculation goes for anything; its only mortal elements being two standard radio tubes good for 1000 continuous hours and used but five minutes a day.

◆ ◆ ◆

Saturation Phenomena in Potential Transformers

Experiences with grounded-neutral Y-connected potential transformers on ungrounded systems emphasize certain dangerous "saturation phenomena" which frequently occur. Two applications are outlined here and preventive measures recommended.

By C. T. Weller

General Engineering Laboratory,
General Electric Company
Member A. I. E. E.

METHODS for preventing the occurrence of the peculiar and dangerous "saturation phenomena" caused by the two applications of Y-connected potential transformers to three-phase, three-wire systems are outlined in this paper. One of the systems operates at 12 kv., 60 cycles, and the other operates at at 110 kv., 25 cycles. In each case the neutral of the potential transformer bank was grounded but the section of the system involved was ungrounded. Although not in accordance with the best practise for power transformers, (because of the apparent suppression of the third harmonic and its multiples of exciting currents), such applications have been made for the affording of protection of equipment against grounds, the economy resulting from the use of L/N instead of L/L (abbreviations L/N for "line-to-neutral" and L/L for "line-to-line" are used) potential transformers and the maintenance of the isolated-phase scheme for such installations.

It may not be generally appreciated that such applications frequently endanger connected equipment in addition to creating special relaying and synchronizing problems. Sufficient data are included to illustrate the inherent danger and to afford a basis for the "general recommendations" made. (For discussions from theoretical standpoints, companion papers, "Physical Nature of Neutral Instability," by A. Boyajian and O. P. McCarty, and "Theory of Abnormal Line-to-Neutral Transformer Voltages," by C. W. La Pierre, are relied upon. These papers were presented at the Southern District meeting in Louisville, Ky., Nov. 19-22, 1930, and are reviewed elsewhere in this issue.)

The potential transformers were designed for normal operation at L/N voltage and for emergency (two-hour) operation at L/L voltage. Temporary operation in case of a ground on one line of the ungrounded section, which would apply L/L voltage to two of the potential transformers, was thus provided. Their ratings are given in Table I.

TABLE I
RATING OF POTENTIAL TRANSFORMERS

		Volts	
Cycles	Volt-amperes	Operating (L/N)	Circuit (L/L)
60	200	7,200:120	12,000
25	1,000	63,500:63.5	110,000

SUMMARY OF RESULTS

The peculiar and dangerous saturation phenomena here described briefly were obtained frequently when voltage was applied to grounded-neutral, Y-connected potential transformers on temporarily ungrounded systems by closing an oil switch; at other times, the anticipated normal results consisting of balanced L/N voltages equal to approximately 58 per cent of the applied L/L voltages were obtained under the same

---

From "Experiences with Grounded-Neutral Y-Connected Potential Transformers on Ungrounded Systems," (No. 30-182) presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

TABLE II
12-KV., 60-CYCLE SYSTEM
7.2-KV. POTENTIAL TRANSFORMERS
COMPARISON OF PHENOMENA *A*, *B*, AND *C* WITH NORMAL SECONDARY VOLTMETER READINGS
(Approximate Primary Volts = Tabulated Volts × 60)

	Line-to-Line (*L/L*)			Line-to-Neutral (*L/N*)			
Per cent*	1-2	2-3	3-1	1-*N*	2-*N*	3-*N*	Phenomenon
Capacitance to ground of 12-kv. circuit, 0.035 μf							
94	194.6	194	196.5	113	115	111	
94	194.2	194	195.2	195	†	180	*A*
100	206	206.5	206.8	195	†	183	*A*
100	206.5	206	207.4	†	174	194	*A*
100	206.5	206.5	208	187	187	†	*A*
104	215.2	215	218	125	126	122	
104	213.4	212.8	215.4	194	†	180	*A*
104	215.8	214	217.6	123	125	122	
104‡	209	207.6	211.5	334.5	331.5	336	*B*
Capacitance to ground of 12-kv. circuit, 0.845 μf.							
100	207	208	209.2	120	119	122	
100‡	197.5	199	200	147	148	149	*C*
113	233.5	235	234.8	134	133	138	
113‡	224	225	227	155	155	155	*C*

*Approximate—based on potential transformer "rating" of 208 volts *L/L* (= 1.73 × 120 volts *L/N*).
†Volts too low to read on 600-volt voltmeter.
‡Supply voltage practically unchanged from previous reading.

system conditions. The operating conditions are indicated in Fig. 1a when "oil switch *I*" is open and voltage is applied to "ungrounded section *U*" from "source *II*" by closing "oil switch *II*." Also, test connections are given in Fig. 3. The phenomena will be considered under three classifications, *A*, *B* and *C*; (a fourth classification *D* covers a somewhat special case). The phenomena are represented in Fig. 2 and are shown in Figs. 4, 5, 6, and 7. Representative secondary voltmeter readings obtained are given in Tables II and III.

Phenomenon *A* consists of a displacement of the neutral (or ground) of the potential transformers from its normal position at the center of gravity of the delta-voltage triangle to a position near any vertex; the displaced neutral may be either inside, on the edge, or outside of the triangle. Approximate *L/L* voltage then appears on two of the potential transformers, while a small voltage of very distorted wave shape appears on the third potential transformer. Phenomenon *A* occurred frequently under some conditions (but not at all under other conditions) on both the 12- and 110-kv. systems.

TABLE III
110-KV., 25-CYCLE SYSTEM
63.5-KV. POTENTIAL TRANSFORMERS
COMPARISON OF PHENOMENON *A* WITH NORMAL SECONDARY VOLTMETER READINGS
(Approximate Primary Volts = Tabulated Volts × 1,000)

	Line-to-Line (*L/L*)			Line-to-Neutral (*L/N*)			
Per cent*	1-2	2-3	3-1	1-*N*	2-*N*	3-*N*	Phenomenon
100‡	110.3	111.8	109.5	64.1	64.2	64	
110	122.7	123.8	121.4	70.4	71.3	70.5	
110	119	121.8	119.2	138.2	22†	129.8	*A*
Duplicate bank of potential transformers added							
100	110.2	111.9	109.8	63.5	64	63	
100	110	110.5	108.3	16†	118.8	122.5	*A*
110	122.2	123.2	122	70.3	71.2	70	
110	121.5	121.7	120.8	13†	114.3	121	*A*

*Approximate—based on potential transformer "rating" of 110 volts *L/L* (= 1.73 × 63.5 volts *L/N*).
†Estimated value.
‡Phenomenon *A* not obtainabl .

Phenomenon *B* consists of an oscillation at double frequency of the neutral (or ground) of the potential transformers outside of the delta-voltage triangle. Equal or balanced voltages of unsymmetrical wave shape and about 2.7 times normal magnitude appear on the three potential transformers. These voltages are accompanied by balanced exciting currents of sharply peaked wave shape and about 10 times rated full-load current in magnitude; operation well up on the saturation curve is indicated thereby. Distinctly audible beats occur with a frequency of from about 30 to 170 per minute; excessive corona also occurs. Phenomenon *B* is represented in Fig. 2c.

Phenomenon *B* started frequently under some conditions but held only long enough to take instrument readings at rated *L/L* voltage or higher on the 12-kv. system; and even then, only at certain times.

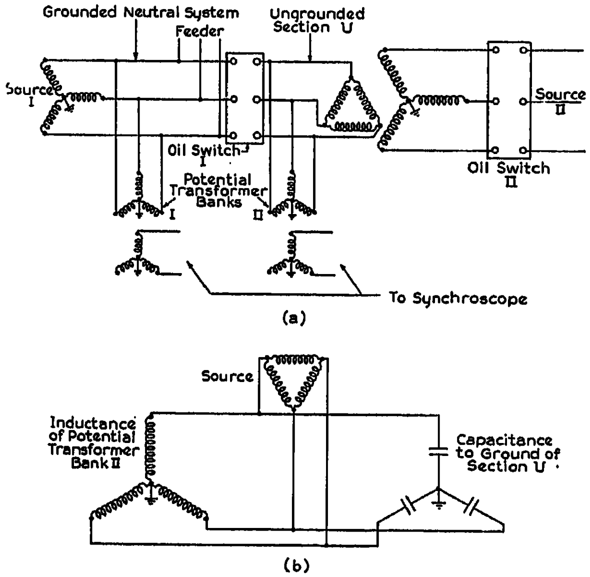


Fig. 1. Schematic Diagrams: (a) typical system connections, (b) elements of circuit U

Phenomenon *C* consists of an oscillation at half the frequency of neutral (or ground) of the potential transformers inside of the delta-voltage triangle. Equal or balanced voltages of unsymmetrical wave shape and about 1.2 times normal magnitude appear on the three potential transformers. These voltages are accompanied by balanced exciting currents of sharply peaked wave shape and about 15 times rated full-load current in magnitude; operation at a point on the saturation curve well beyond that for phenomenon *B* is indicated thereby. Distinctly audible beats occur with a frequency of about 240 per minute. Phenomenon *C* occurred frequently under one condition only on the 12-kv. system.

The occurrence of phenomena *A*, *B*, and *C*, as shown by sustained instrument readings, was prevented in all cases by adding sufficient secondary burdens of resistance. The values (at 120 volts) of the protective resistor burdens required on the 12-kv. system are as follows: phenomenon *A*, at all voltages tried, 72-volt-amperes; phenomenon *B*, about 20 volt-amperes; phenomenon *C* at rated *L/L* voltage, 72 volt-amperes. A burden of 72 volt-amperes, therefore, was provided for each transformer. Similarly, the burden values (at 63.5 volts) required on the 110-kv. system are: phenomenon *A* (and *B*) at all voltages tried, 900 volt-amperes per transformer with one bank of potential transformers or 600 volt-amperes per transformer with two banks of potential transformers.

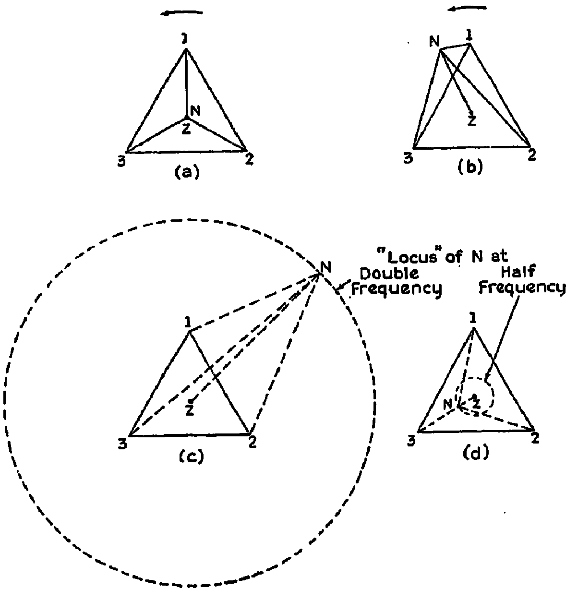


Fig. 2 Representations of voltage phenomena by means of vectors

(a) Normal condition, neutral *N* coincides with center of gravity *Z* of delta-voltage triangle 1-2-3. (b) Phenomenon *A*, neutral *N* located near one vertex of delta-voltage triangle 1-2-3. (c) Phenomenon *B*, neutral *N* oscillates at double frequency outside of delta-voltage triangle 1-2-3. (d) Phenomenon *C*, neutral *N* oscillates at half frequency inside of delta-voltage triangle 1-2-3.

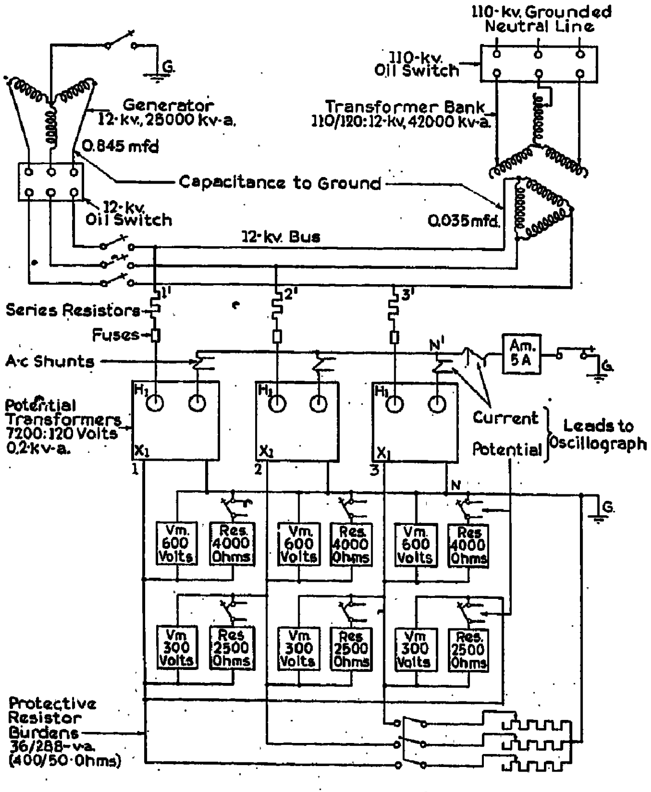


Fig. 3. Schematic diagram of connections for tests on 12-kv., 60-cycle system

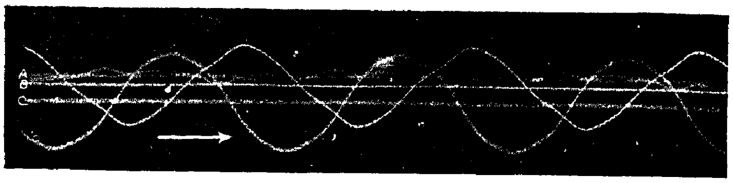


Fig. 4. 7.2-Kv. potential transformers—phenomenon A

Curve *A*, voltage 2-*N*; curve *B*, voltage 3-*N*; curve *C*, voltage *N*-1

In further tests made on the 12-kv. system (capacitance to ground 0.035 μf.), phenomena *A* and *B* also occurred when a bank of 13.2-kv. potential transformers was connected in multiple with the bank of 7.2-kv. transformers; however, neither *A* nor *B* occurred when the 7.2-kv. bank was disconnected.

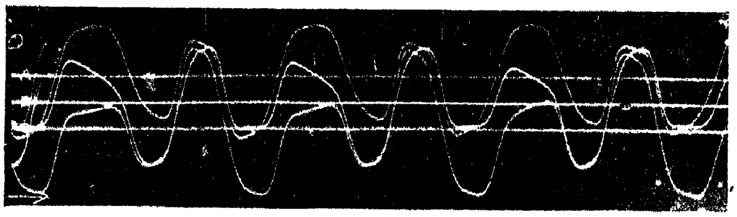


Fig. 5a. 7.2-Kv. potential transformers phenomenon B

Curve *A*, voltage 3-*N*; curve *B*, voltage 2-*N*; curve *C*, voltage 1-*N*

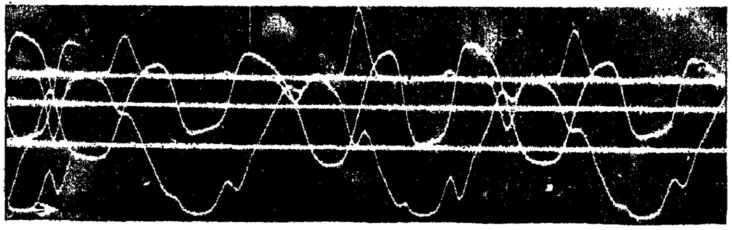


Fig. 5b. 7.2-Kv. potential transformers—phenomenon B

Curve *A*, current line 2'; curve *B*, voltage 2-*N*; curve *C*, voltage 3-2

Phenomenon *B* occurred when a bank of 6.9 kv., 1.5-kv-a. distribution transformers was connected in alone. A different phenomenon (*D*) occurred when the 5.96-kv. tap on this bank was used (this tap of course would not be used in practise on a 7.2-kv. circuit). Phenomenon *D* consisted of an oscillation at triple frequency of the neutral (or ground) outside of the delta-voltage triangle; equal or balanced voltages of about 3.5 times normal appear on the three transformers; audible "buzzing" and excessive corona occur. Phenomenon *D* did not hold long enough at any time to obtain a complete set of instrument readings; evidently D is easier to prevent than B.

SIGNIFICANCE OF RESULTS

Phenomena A, B, and C and the conditions under which they occur are not characteristic of any particular ungrounded system or type of transformer. As phenomena B and C endanger the potential transformers themselves so the former also endangers other connected equipment. All three phenomena tend to cause incorrect synchronizing and incorrect relay operation; the difficulties depend to some extent on the secondary connections used.

Fig. 6.   7.2-Kv. potential transformers— phenomenon C

Curve A, voltage 3-N; curve B, current line 3′; curve C, voltage 1-3

Y-Connected Secondaries. Ordinarily, if any one of the L/N voltages should be chosen for synchronizing purposes, it is evident that the indications frequently obtained would be considerably in error both in magnitude and in phase position, to say nothing of wave shape and frequency. This particular difficulty could be overcome readily by using any one of the L/L voltages; however, the correct effective secondary values would not be indicated by the voltmeters for phenomena B or C, although this error would be small (see Table II); also, there might be some disturbance caused by throwing together two systems, one of which was being subjected to phenomena A, B or C.

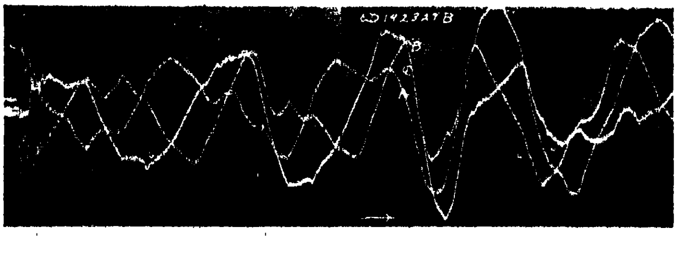


Fig. 7.   Six 63.5-Kv. potential transformers (two Y-banks)—start of phenomenon A (and B)

Curve A, voltage 3-N; curve B, voltage 2-N; curve C, voltage 1-N

"Broken-Delta"-Connected Secondaries. Ordinarily, the high-impedance "ground relay" connected across the "broken-delta" would operate frequently, although no accidental ground existed on the system.

These difficulties can be overcome in various ways; such as by grounding the sections of the system, by using the L/L connection for all potential transformers, by providing protective resistor burdens for L/N-rated potential transformers or by using potential transformers of considerably higher than L/N-voltage ratings for the L/N connection, and thereby lowering the point on the saturation curve at which the transformers normally operate.

GENERAL RECOMMENDATIONS

These recommendations are intended to serve as a guide in the application of grounded-neutral, Y-connected potential transformers to three-phase, three-wire systems or sections thereof, which temporarily or permanently are ungrounded.

TABLE IV
APPROXIMATE RELATIVE VALUES OF PROTECTIVE RESISTOR BURDENS REQUIRED TO PREVENT OCCURRENCE OF PHENOMENA A, B, AND C

	Y-Connected Potential Transformers		
System or Section Neutral	Primary Neutral	Normal Voltage Rating	Relative Value of Burdens
Ungrounded temporarily	Grounded	L/N	1.0
	Grounded	L/L	0.5
	Grounded	$2 \times L/N$	
Ungrounded permanently	Grounded	L/N	1.5
	Grounded	L/L	0.75
	Grounded	$2 \times L/N$	0.25

Protective resistor burdens should be used in practically all cases if the occurrence of phenomena A, B, and C is to be prevented under all possible operating conditions. It is always desirable to keep the volt-ampere ratings of such burdens as small as possible and this involves a consideration of the characteristics of each proposed installation. The magnitude of the burdens provided for the potential transformers of L/N-voltage design on the 12-kv. and 110-kv. systems was determined experimentally and a rough idea of the general requirements was thereby obtained; the magnitude of these burdens constitutes the standard of reference for the relative values in Table IV.

A differentiation is made in Table IV between temporarily and permanently ungrounded systems. The ratio of the volt-ampere ratings of the protective burdens recommended for the two conditions is about 1 to 1.5. It is believed that a greater margin of safety is desirable for permanently ungrounded systems, since they are always subject to disturbances tending to displace the neutral from its normal position; installations of potential transformers on such systems have not been investigated.

Physical Nature of Neutral Instability

Experience has established the fact that three-phase-system neutrals may become subject to strange phenomena of instability under apparently normal conditions. The authors give facts and explanations based upon extensive experimentation.

By A. Boyajian *and* *O. P. McCarty*

General Electric Company
Pittsfield, Mass.
Fellow A. I. E. E.

General Electric Company
Pittsfield, Mass.
Associate A. I. E. E.

FROM time to time the attention of the Institute has been drawn to some peculiar troubles accompanying the operation of power or potential transformers connected Y-Y with grounded neutral on an otherwise isolated system. (See bibliography) The phenomena under discussion are found only in circuits with capacitance and saturation, and therefore it is proposed to build up the present discussion starting with an analysis of the characteristics of iron-core reactors in combination with capacitors.

Iron-Core Reactor Shunted by a Capacitor. When the volt-ampere characteristics of a saturating inductance (such as the magnetizing current of a transformer) and of the shunt capacitance are plotted, the resultant characteristic curve of the combination is as shown by the curve of Fig. 1. It is realized that the exciting current of a transformer is much more complicated than that of a capacitor. While the latter may be considered as yielding a pure leading current, the former always will contain a lagging component, a power component, and harmonics. Since the lagging component frequently is 80 or 90 per cent of the total exciting current, its behavior in the network is of importance.

Negative or Leading Reactance Zone O-A (Fig. 1). In this zone I_o is leading and the combination behaves like a negative, or capacitative, reactance. As the graph is substantially straight the circuit parameter (the equivalent reactance of the combination) is constant, and like any linear impedance the behavior of the outfit in a network in combination with other impedances is stable.

Unstable Zone A-B (Fig. 1). In this zone the resultant current I_o still is leading, but instead of increasing with increasing voltage it diminishes. Consequently while the gross apparent reactance still is negative, leading, or capacitative, the differential or incremental reactance (the reactance for increases or reductions in current) is positive, lagging, or inductive. Thus,

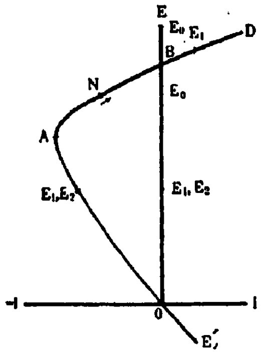
$$X \text{ considered as } \frac{E}{I} \text{ is negative, leading, capacitative,}$$

and

$$X \text{ considered as } \frac{\Delta E}{\Delta I} \text{ is positive, lagging, inductive.}$$

Such a characteristic *under suitable network conditions* may become a source of instability somewhat analogous to the case of an arc.

Positive or Lagging Reactance Zone B-D (Fig. 1) In this zone the current is lagging and increases with the voltage (even though not in exactly direct ratio). Thus both the gross and the incremental reactance of the combination are lagging or inductive, therefore the behavior of the combination is approximately that of a plain saturating inductive reactance. An equilibrium point in this zone tends to be stable.



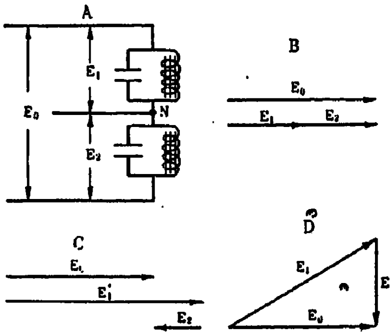


Fig. 1. (Left) Resultant volt-ampere curve of an iron-core reactor with capacitor in parallel

Fig. 2. (Right) Inversion in a single-phase circuit

(A) Single-phase circuit with unstable neutral
(B) Vector diagram for normal neutral condition
(C) Vector diagram for inverted neutral
(D) Same as (C) with prominent quadrature component

A Multiple-Valued Function. Aside from the change in the value and algebraic sign of the resultant reactance from zone to zone of the characteristic curve, another interesting feature to observe is the double-valued character of the curve. Over a wide range, including *O-A*, *A-B* and part of *B-D*, and the corresponding zones below the horizontal axis, there are to any given value of current, two totally different possible values of voltage.

Resonance and Natural Frequency. At point *B* (Fig. 1), where the resultant current I_o is zero, there is parallel resonance at impressed frequency, that is, the outfit has a natural frequency of oscillation equal to that of the impressed voltage. In such circuits currents undoubtedly are distorted, but that does not invalidate conceptions of resonance and free oscillations.

Classification of Abnormal Phenomena. In analyzing the various abnormal phenomena it is found that

---

From "Physical Nature of Neutral Stability," (No. 31-186) presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

they fall into two distinctive groups—(1) those which involve merely a shifting or inversion of the neutral and are primarily phenomena of fundamental impressed frequency; and (2) those which do not disturb the fundamental frequency voltages, but introduces an oscillation into the neutral, higher or lower than the impressed frequency.

I—Inversion of Neutral

Inversion in a Single-phase Circuit. Referring to Fig. 2A, let branches 1 and 2 be duplicates; a point of equilibrium for N obviously is half-way between the potentials of the terminals, as shown in Fig. 1 and also by the vector diagram of Fig. 2B: where

$$E_1 = E_2 = E_0/2,$$

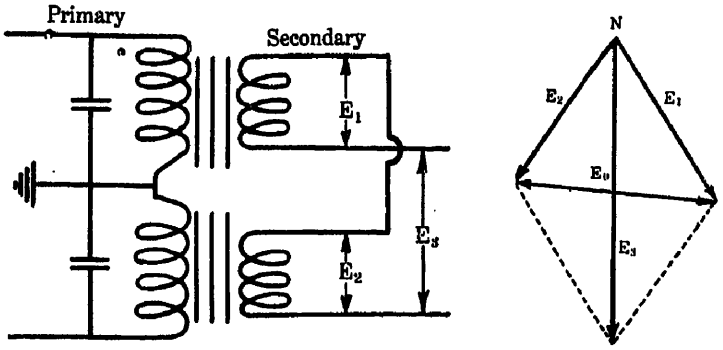


Fig. 3. (Left) Circuit for single-phase neutral instability tests, and (Right) vector diagram showing neutral shift

where E_0 is the line voltage, and E_1 and E_2 are the branch voltages. If the branch voltages E_1 and E_2 are within the zone O-A (as shown in Fig. 1), the potential of N once so established (Fig. 2B) will be normal and stable. The line current will be leading, both branches acting capacitatively. Assume, however, that when the line switch is closed, the starting transient unbalances the voltages and carries one of the branch voltages, say E_1, into zone A-D; a new and abnormal condition of equilibrium may now become established as follows:

Considering the characteristic curve (Fig. 1), it is seen that not only

$$E_1 + E_2 = E_0,$$

but also,

$$E_1' + E_2' = E_0.$$

In the latter case, E_2' is negative, E_1' is greater than the line voltage (see also the vector diagram of Fig. 2C), and the neutral potential is outside of the line voltage. Obviously, one leg or branch of the circuit is acting inductively; the other, capacitatively.

With a different line voltage say E_0'' (Fig. 1)—a still different type of abnormal equilibrium may take place with the leg or branch voltages assuming the values E_1 and E_2 respectively, in which case then, both branches are operating capacitatively, one overexcited, the other underexcited. A still different position of the neutral may correspond to one leg operating in the zone A-B, the other in the zone B-D, both legs overexcited. Such a case was observed in single-phase tests.

Inversion in a Three-Phase Circuit. If the neutral of a Y-Y or Y-broken-delta bank of transformers is grounded on a circuit which otherwise is isolated, the neutral of the transformers is joined to the neutral of the line capacitance to ground, resulting in an equivalent circuit such as shown in Fig. 5. Each leg of this network will have a volt-ampere characteristic similar to Fig. 1, capable of acting either as a capacitative reactance or as an inductive reactance.

Assuming the three legs to be duplicates, the normal position of the neutral will be at the center of gravity of the line voltage triangle. However, other positions of equilibrium also exist, for instance, two of the legs operating in the zone B-D with a lagging power factor, and the third in the zone O-A with a leading power factor, as explained for the single-phase circuit, in which case one leg will be reversed and the other two will be greatly overexcited; the neutral will fall outside of the triangle of line voltages. The alternative case, in which all the legs operate capacitatively, one in the zone O-A, the other two in the zone A-B, as discussed in connection with single-phase neutral shift (the neutral falling just inside the line voltages) also has been observed. (See companion paper by C. T. Weller.)

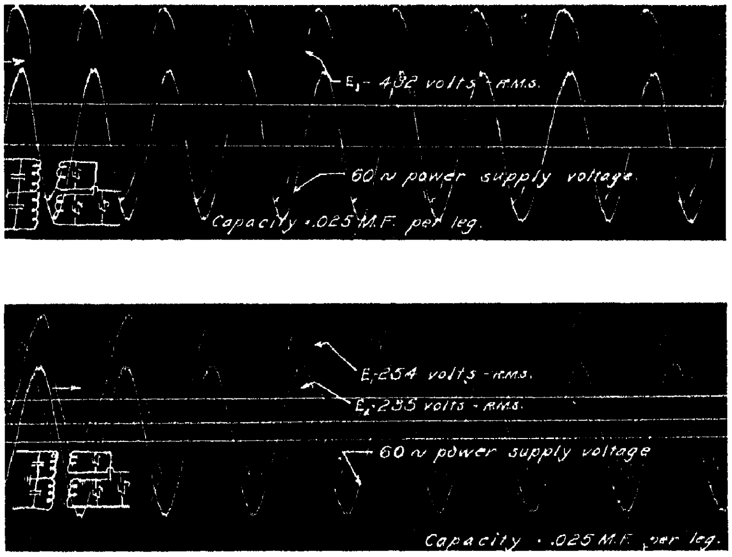


Fig. 4. Oscillograms showing neutral shift in circuit of Fig. 3

Since any one of the legs may become underexcited, depending upon the instant of switching, there will be at least three abnormal stable positions of the neutral.

Single-Phase Inversion Tests

Two duplicate standard potential transformers, rated 13,200/100 volts, were connected in series to yield a neutral point as shown in Fig. 3, and each transformer was shunted by a variable capacitance the settings of which were made alike in all cases. When the circuit voltage was brought up gradually the neutral was found to be normal in all cases. However, when the voltage to the circuit was applied suddenly, inversion of the neutral point was observed over a fairly wide range of capacitances, this range depending on the excitation of the transformers. The secondaries (low-voltage) of the potential transformers may be seen connected in series-opposition to segregate the abnormal voltage component of the neutral. Obviously, with balanced branch voltages the terminal voltage of the secondaries as connected would be zero, but if the neutral should shift, invert, or oscillate, the phenomenon will appear in the resultant voltage of the two secondaries in its pure form, unmixed with normal voltage.

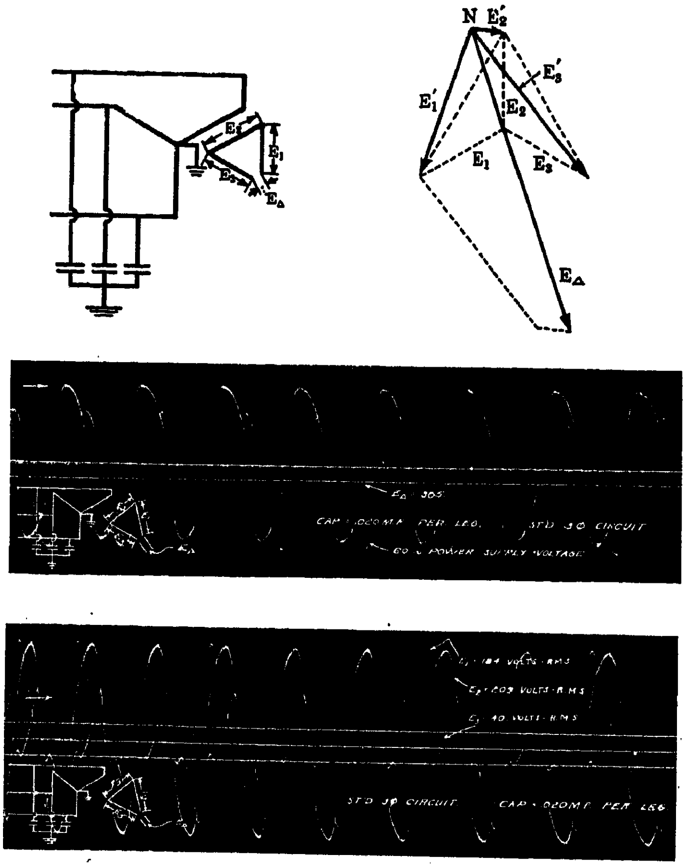


Fig. 5. Circuit and test results for three-phase-neutral instability

With line voltages representing from 100 to 120 per cent excitation on the potential transformers the neutral of this single-phase bank frequently would come in inverted, with capacitances of from 0.025 to 0.050 mfd. across each unit (on the high voltage side). With line voltage representing 120 per cent excitation, a typical set of readings gave $E_1 = 193\%$, $E_2 = 178\%$, and $E_3 = 328\%$ of the values corresponding to normal neutral.

The oscillogram of Fig. 4 shows that all voltages are of fundamental frequency and reasonably good wave shape. The vector diagram of Fig. 3 shows the branch voltages to be of the same order of magnitude, and the neutral to have shifted almost in quadrature with the impressed voltage. The significance of this is that one of the branches is operating capacitatively in the zone *A-B* (Fig. 1) fairly close to *B*, the other inductively in the zone *B-D*, but again fairly close to *B*. Only such a combination will give an inversion in which E_1 and E_2 will be so nearly equal.

Three-Phase Inversion Tests

The circuit is shown in Fig. 5; it should be observed that when the neutral is normal the voltage across the corner of the delta will be zero; but when the neutral moves from this position it will show in the corner of the delta. Thus, only those phenomena which disturb the neutral can appear across the corner of the delta; all others cancel out. Voltage oscillograms taken at this point therefore show clearly the nature of the disturbance of the neutral. The magnitude of this voltage will be three times the corresponding component in each leg. The vector diagram of a typical case of inversion is shown in Fig. 5.

The oscillograms of Fig. 5 give evidence that the phenomena are of fundamental frequency and of reasonably good wave shape. The data show that two legs are overexcited (acting inductively) and one underexcited (acting capacitatively). The fact that the neutral shift is not exactly parallel to the normal leg voltage of the underexcited leg is due largely to the losses.

It was observed that upon switching in, any one of the three legs might come in reversed.

II. Oscillating Neutral

Oscillations at half, double, and triple frequencies, with low-frequency beats and high-frequency harmonics also have been observed.

In Fig. 7 is illustrated a single-phase case in which the oscillation persisted indefinitely. Note the purity of the wave shape and that it is exactly one-half of the impressed frequency. In examining the waves of the leg voltages (E_1 and E_2) nothing else of importance is found other than a fundamental and a half-frequency harmonic.

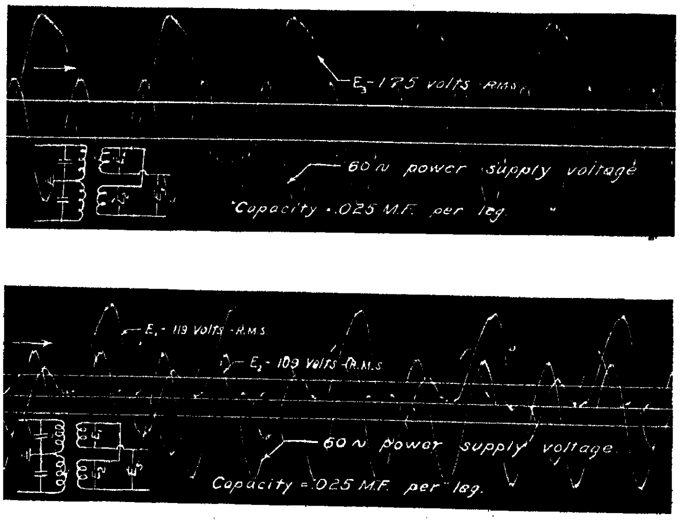


Fig. 6. Oscillograms of oscillating single-phase neutral

In Fig. 8 is given the timing wave (supply voltage), leg voltage and the neutral voltage for a typical case of oscillation in a three-phase circuit. The neutral voltage is observed across the corner of the delta. The characters of these waves may be seen to be substantially the same as in the single-phase tests.

The explanation of the persistance of such oscillations is as follows:

It is commonly known that a Y-open-delta transformer can be used to derive triple-frequency single-phase power from a fundamental-frequency three-phase source. For instance, at nominal 60-cycle densities around 170 kilolines per sq. in., third-harmonic outputs as high as 100 kw. per 1,000 lb. of core can be obtained. This flow of power must be reversible, that is, if the harmonic current is reversed, power must flow from the harmonic to the fundamental.

The free oscillation naturally will be distorted and have higher harmonics. If the impressed frequency is identical with one of these harmonics, power can flow from it to the oscillation as from a higher harmonic to its fundamental, to take care of its watt losses.

A harmonic can deliver to the oscillation not only a certain amount of watts, but also a certain amount of reactive volt-amperes. This is most significant because it makes persistence of oscillations possible without exact resonance. For instance, if the supply frequency is 60 cycles and the natural frequency of oscillation of the circuit is 21 cycles the circuit may oscillate at one-third frequency or 20 cycles just as readily. The difference between oscillating a little off-resonance (20 cycles) and at exactly free resonance (21 cycles) is that the latter requires watts for its maintenance, while the former requires both watts and reactive volt-amperes.

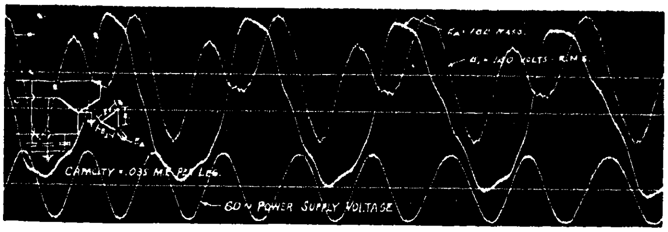


Fig. 7. Oscillogram of oscillating three-phase neutral

Thus, within the extent of the ability of the oscillation to draw watts through one of its harmonics, a free oscillation can be maintained with higher and higher losses; while, within the ability of the oscillation to draw reactive volt-amperes through one of its harmonics, a free oscillation can be maintained farther and farther off from the true natural frequency of the circuit.

CONCLUSIONS

1. Operation of potential transformers in Y-Y with neutral grounded on an otherwise isolated system, (whether permanently or occasionally isolated system, or section of a system), is a somewhat questionable practise unless protective measures are used.
2. Aside from possible trouble due to third-harmonic-voltage intensification, which is so well-known, it is found that with favorable capacitance values from line to ground, natural oscillations are possible around one-half normal frequency as well as double normal frequency.
3. Aside from oscillations, there is the possibility of the inversion of the neutral being unsafe for equipment.
4. Explanation of the neutral shift or inversion is based upon the fact that the combination of a saturable inductance and a constant capacitance has a multi-valued characteristic curve, with leading and lagging zones. For instance, if one leg operates in a leading zone and the other two in a lagging zone, the potential of the neutral is thrown outside of the triangle of line voltages.
5. Persistence of oscillations is accounted for as follows: The frequency of the free oscillation of the circuit must approximate harmonic relationship to the impressed frequency. When the oscillation is at a frequency higher than the impressed, the active and reactive energy flow to it is similar to that from fundamental to higher harmonics, as in static frequency multipliers. When the oscillation frequency is lower, such as one-half of the impressed frequency, the impressed frequency stands in the relationship of a higher harmonic of the oscillatory frequency and the energy flow is reversed because the location of power and load are interchanged.
6. In potential transformer banks intended exclusively for relaying purposes the secondary (or a tertiary) could be connected in delta, and closed through a resistance just high enough to protect the bank from burnout in times of line-to-neutral short circuits; then troubles due either to inversion or oscillation would be entirely eliminated. However, if the bank is to be used for metering as well as for relaying, th currents circulating in the delta due to unbalanced line-to-neutral conditions in the system may affect adversely the metering accuracy of the outfit.
7. Loading the potential transformer from line to neutral also tends to stabilize the neutral and prevent inversion and oscillations. However, this will be a constant load at impressed frequency. It is believed that such a load should be *at least* of the same order of magnitude as the magnetizing volt-amperes of the transformers at normal operating voltage.
8. Operation of potential transformers approximately at half rated voltage is found to reduce greatly the chances of self-excited oscillations. The damping load of the order of the magnetizing volt-amperes at such low excitations is small and well worth-while. Low-density operation and protective load are desirable also from the standpoint of third-harmonic phenomena.

◆ ◆ ◆

Progress in Fuel Utilization

IN discussing progress in development and application of boilers and furnaces a recent report of the Fuels Division, The American Society of Mechanical Engineers, says in part:

"The trend toward higher steam pressures and temperatures continues not only in public utility plants but also in industrial plants. Boiler manufacturers are in position to erect commercial units supplying steam up to 1800 lb. per sq. in. and 850 deg. fahr. total temperature. A boiler of the series type suitable for delivering steam at 3,500 lb. pressure is being completed by the Babcock & Wilcox Company and is to be given to Purdue University for experimental work. An experimental and special form of superheater installed at the Detroit Edison Company has operated successfully for some time, delivering steam at practically 1,200 deg. fahr.

"The many novel ideas in boiler-furnace design which have been incorporated in the past few years have received exhaustive tests in commercial operation and the wealth of combustion data thus accumulated has served to eliminate unnecessary refinements. Early enthusiasm over the performance of furnace water walls has been somewhat tempered, and an economical limit for their use has been found in moderate- and small-sized boilers operating under certain restricted conditions.

"Considerable improvement in combustion conditions with stoker-fired boilers has been attained by means of judiciously proportioned water-cooled protecting walls and arches. Simultaneously the air-cooled and sectionally supported refractory walls have amply justified expectations in many cases. Notable progress has been made in the rate of firing per boiler unit. The record-breaking performance of the new boilers at the East River station of the New York Edison Company is due mostly to the excellent functioning of the fin-tube furnace of 39,000-cu. ft. volume, where up to 75 tons of powdered coal have been burned per hour."

◆ ◆ ◆

Theory of Abnormal Voltages

Abnormal line-to-neutral transformer voltages may be said to be self-excited by successive alternate saturations and limited in magnitude and frequency by multiple saturations. Outline of theory is given here.

By C. W. LaPierre

General Engineering Laboratory,
General Electric Company,
Schenectady
Associate A. I. E. E.

ABNORMAL voltages considered in this paper arise incident to the occurrence of a large harmonic of fractional, even, or odd frequency in the line-to-neutral voltages of certain Y-connected transformer circuits. These phenomena have been described before (see Bibliography) and additional data concerning them are available in the two companion papers reviewed elsewhere in this issue,—one by C. T. Weller and one by A. Boyajian and O. P. McCarty.

ABNORMAL VOLTAGES

The circuit in which the phenomena occur is represented by Fig. 1A or Fig. 1B. The abnormal harmonic is a zero-phase-sequence component existing in the transformer or line-to-neutral voltages. The frequency of this harmonic and, to a lesser extent, its magnitude, are of special interest. In the transient state occurring soon after the circuit is connected to the source the harmonic voltage may be so highly irregular as not to possess a definite frequency. However, after the voltages continue for a while they either disappear altogether or settle down to a fairly constant frequency and magnitude. In these sustained conditions the frequency of the predominant harmonic has been observed to be either one-half of, equal to, double, or triple, the supply-voltage frequency; the problem is clarified, however, if it is realized at once that these frequencies are only special cases of the irregular transients. For the latter, all frequencies are possible (within wide limits), whereas in the former only four are found to occur.

In this abstract the fundamental origin of all of the abnormal voltages is explained. The conditions surrounding the occurrence of sustained voltages are discussed in detail in the complete paper.

The fundamental explanation of the abnormal voltages just described is quite simple; the explanation is handicapped, however, by the complexity of the representative circuits of Fig. 1. An analysis of these circuits must involve the three line-to-neutral or transformer voltages, and the three transformer and three capacitor currents. Add to this a 5,000:1 variation in the open-circuit inductance of each transformer and the problem becomes even more formidable. Obviously the procedure must be simplified. In this paper the simplification has been accomplished by the adoption of an equivalent circuit.

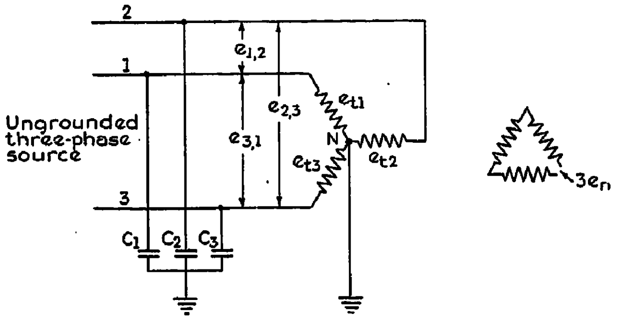


Fig. 1A. Representative circuit

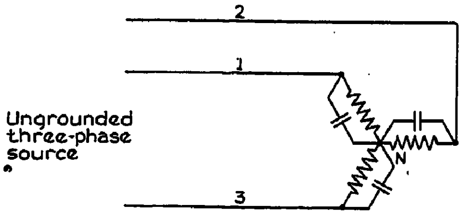


Fig. 1B. Simplified representative circuit

Although Fig. 1A represents the circuits in which the phenomena have been observed to occur, the equivalent circuit of Fig. 2A may be expected to produce the same tranformer voltages and is identical in that respect to Fig. 1A under certain conditions. In Fig. 2A the capacitor voltage is equivalent to the neutral or harmonic voltage and may be visualized directly without the necessity of separating it from the transformer

---

From "Theory of Abnormal Line-to-Neutral Transformer Voltages," (No. 30-184) presented at A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

voltage as is the case in Fig. 1A. It is the variation in the voltage across this capacitor which introduces the harmonics in the transformer voltages; furthermore, in Fig. 2A the capacitor or neutral voltage is the only voltage that must be determined. The three transformer voltages may be obtained by simply adding the capacitor or neutral voltage to each of the known supply voltages.

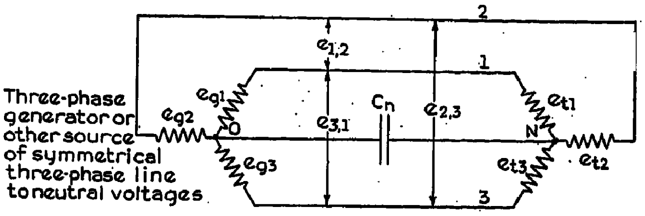

2
$e_{1,2}$
1
Three-phase generator or other source of symmetrical three-phase line to neutral voltages
e_{g1}
e_{g2}
O
$e_{3,1}$
C_n
$e_{2,3}$
e_{t1}
N
e_{g3}
e_{t3}
e_{t2}
3

Fig. 2A. Equivalent circuit

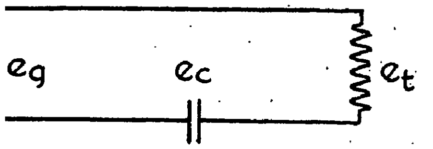


Fig. 2B. Single-phase circuit

Thus by adopting a particular type of supply it is possible to reduce the problem to a consideration of the voltage across a single capacitor. While it is theoretically immaterial which figure is used in the following discussion, the processes to be described will have far greater practical significance if they are based upon Fig. 2A.

ORIGIN OF ABNORMAL VOLTAGES

Saturation during the first cycle after connecting a transformer to a source of voltage is of common occurrence. Such saturations are the result of initial conditions of voltage and residual core densities. In transformers connected directly across a single-phase supply, the initial saturation results in the familiar starting currents represented by Fig. 3. This curve actually consists of a succession of saturations, all in the same direction. Magnitude of the peaks gradually diminishes until normal densities are not exceeded. Each saturation is an individual event consisting of a rise of the current and flux along the hysteresis loop of Fig. 4 and their subsequent decay to normal values. The large current accompanying a single saturation is unidirectional; it cannot become a large reversed current until after the core density reaches saturation values in the opposite direction.

Referring to Fig. 2A (or Fig. 1A), assume the chance occurrence of a single saturation a short time after the supply switch is closed; the resulting unidirectional current must flow into the system capacitance since the unsaturated transformers will not pass any appreciable part of this current. The current flowing into the capacitance builds up a unidirectional capacitor voltage; this voltage continues to rise until the cycle of saturation is completed, at which time the transformer is restored to normal densities. With all of the transformers at normal densities, their impedances are too high to permit the capacitor to be discharged; consequently, the capacitance voltage will be maintained practically constant for the time being.

This action of a single saturation in the circuit is not unlike that of a valve; it injects a large current into the capacitance and then closes the entrance path to prevent its discharge. The magnitudes of the various changes resulting from a single saturation are dependent to a large extent upon the circuit constants, such as capacitance, normal transformer flux densities, size of core, number of turns, etc. It is not necessary to consider these factors at the outset because the fundamental nature of the phenomena may be explained on the assumption that a sufficiently large capacitance is present, and that saturations do occur.

Voltage changes resulting from the saturating process may be readily visualized with the aid of Fig. 5. The dashed-line curves in this figure may be recognized as the three normal line-to-neutral transformer voltages. Assume the switch to be closed at t_0 and that due to the initial conditions the transformer of phase 2 saturates at time t_1; in accordance with the preceding discussion, the saturation of phase 2 will result in an abrupt rise in the capacitance or neutral voltage. For the purpose of illustration this rise may be assumed as vertical. After the single saturation is completed, the high impedance of the transformers prevents the capacitance from discharging and for the time being the neutral voltage remains constant. However, the voltage which the capacitance has acquired adds to the voltage of phase 1 to result in an abnormally large voltage across its transformer. The large voltage, which in the figure is about twice normal, will saturate transformer No. 1 at about t_2. The second saturation is in the opposite direction to the first and consequently results in a reversal of the neutral voltage.

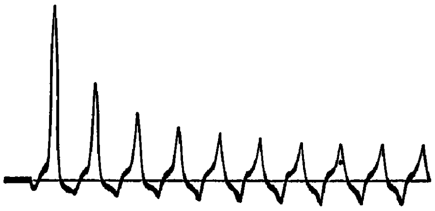


Fig. 3. Transformer starting current

In case it is not clear that the second saturation occurring at t_2 would reverse the capacitor voltage, reference is made to the hysteresis loop of Fig. 4. Once a saturation starts, it will increase in intensity until the transformer voltage reaches zero; so long as there is some voltage, the flux continues to increase. After the flux reaches a maximum, at the instant the transformer voltage reaches zero, it must decline to its residual value. This partial collapse of the magnetic field induces a transformer voltage in the opposite direction. Consequently in Fig. 5, whenever a saturation is assumed to occur, the affected transformer voltage should be reversed by an appreciable amount and the neutral and other voltages determined by subtraction and addition.

The neutral voltage acquired at t_2 remains constant as before, while the transformers operate in the range of normal densities. Again the neutral voltage results in an abnormally large voltage across the transformer of phase 1 and it probably will saturate at t_3 in the opposite direction. This saturation reverses the neutral voltage a third time and the process may be continued for the fourth, fifth, and sixth saturations; and so on indefinitely.

In essentials, Fig. 5 illustrates the origin of the abnormal voltages of this discussion, although the actual wave shapes obtained are not rectilinear. It is evident that the frequency of the voltages is dependent only upon the rate at which the saturations occur and it is not surprising that unusual frequencies have been observed.

At the start when there are wide differences between the core conditions of the three transformers, the saturations occur in a more or less hit-or-miss fashion and the resulting neutral voltages are highly irregular. As the initial differences in core conditions begin to be smoothed out, the time of saturation becomes more and more dependent upon how the neutral voltages combine with the supply voltages. For the voltages to reach a sustained condition it is necessary that some sort of stabilizing process be present which will maintain the voltages within a stable zone. This requirement is satisfied by the formation of multiple saturations or the saturation of two or more transformers in parallel and in the same direction. (Direction of saturation as used here has a very definite meaning when referred to either Fig. 1A or Fig. 2A. Two or more saturations are in the same direction when their respective currents flow in the same direction at the neutral; that is, either out or in.) The proper stabilizing multiple saturations occur only for a limited number of neutral-voltage frequencies,—namely, one-half of, equal to, double, and triple the supply-voltage frequency; consequently these are the only frequencies which can become stable and reach the sustained condition.

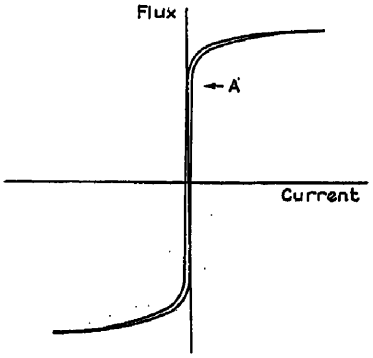


Fig. 4. Hysteresis loop

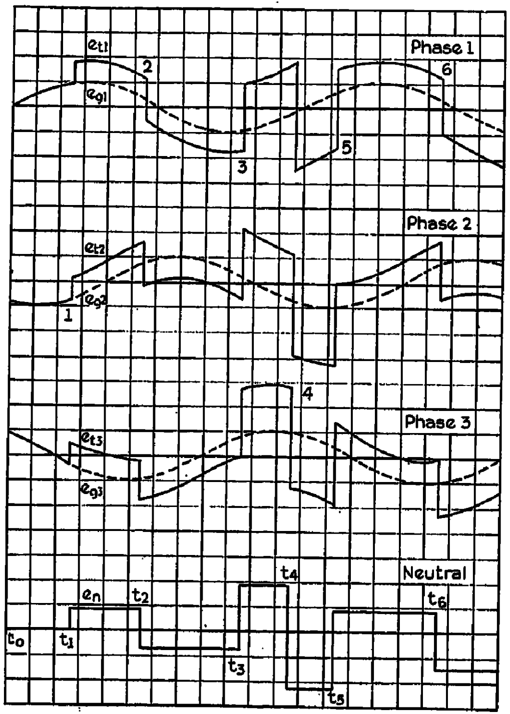


Fig. 5. Hypothetical voltages resulting from an arbitrary succession of saturations ($e_t = e_n + e_g$)

CONCLUSIONS

In accordance with the preceding discussion the abnormal voltages may be said to be self-excited by successive alternate saturations and limited in magnitude and frequency by multiple saturations. The complete theory based upon these two principles explains in an adequate manner the observed characteristics of the phenomena.

BIBLIOGRAPHY

Phenomena Accompanying Transmission with Some Types of Star Transformer Connections, by L. N. Robinson, Trans. A. I. E. E., Vol. XXXIV, 1915, p. 2183. Also Part II of this paper, Trans. A. I. E. E., Vol. XXXVI, 1917, p. 1081.

Instability in Transformer Banks, by K. E. Gould, Trans. A. I. E. E., Vol. XLVI, 1927, p. 676.

Harmonics of Double and Fractional Frequency in Three-Phase Networks with Star-Star-Connected Transformers and Grounded Neutral, *Archiv fur Electrotech.*, Vol. 22, 1929, p. 588.

Experiences with Grounded-Neutral Y-Connected Potential Transformers on Ungrounded Systems, by C. T. Weller, A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

Physical Nature of Neutral Instability, by A. Boyajian and O. P. McCarty, A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

Graphical Construction of Hyperbolic Functions

By W. F. Helwig

Assistant Professor of Electrical Engineering
Texas Technological College

TRANSMISSION line calculations requiring the use of complex hyperbolic functions are materially simplified through the construction and use of a chart from which both the complex hyperbolic sine and cosine values may be determined in either polar or complex-number form. The device is a polar rectangular chart combined with a specially constructed scale graduated in values of $\frac{\epsilon^{a}}{2}$ and $\frac{\epsilon^{-a}}{2}$. The chart should be constructed with angles in circular radians and degrees which may be divided into convenient values. In constructing such a chart for practical use it may be convenient to employ heavy lines to denote each interval of 5 deg. and to subdivide these into degrees by fine lines. Ordinary cross-section paper having ten lines per inch is suitable for the rectangular chart.

Theory underlying the construction of the chart is given in the mathematical expressions:

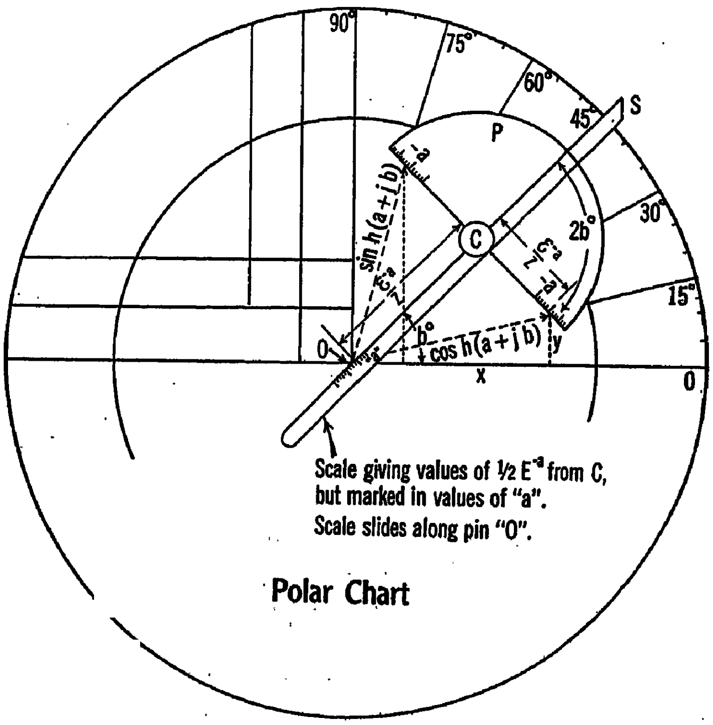
$$\begin{aligned}
\cosh(a + j\,b) &= \frac{1}{2}\left[\epsilon^{(a+jb)} + \epsilon^{-(a+jb)}\right] \\
&= \frac{\epsilon^{a}\,\epsilon^{jb}}{2} + \frac{\epsilon^{-a}\,\epsilon^{-jb}}{2} \\
&= \frac{\epsilon^{a}}{2}(\cos b + j\sin b) \\
&\quad + \frac{\epsilon^{-a}}{2}(\cos b - j\sin b) \\
&= \dot{V}_1 + \dot{V}_2 \qquad \text{(plane vectors)}
\end{aligned}$$

Similarly $\sinh(a + j\,b) = \dot{V}_1 - \dot{V}_2$

PROCEDURE

Referring to the accompanying illustration, $O\,C$ is equal to $\frac{\epsilon^{a}}{2}$ and is laid off at the proper angle b on the circumference of circle S (this is $\pi/4$ or 45 deg. in the example given). Thus $\dot{V}_1$ is laid off in proper direction and magnitude. Next, the protractor, pivoted at the point C to the scale representing vector $\dot{V}_1$, is turned until its scale $\left(\text{graduated to values of } \frac{\epsilon^{-a}}{2}\right)$ lies at the angle $-\,b$ with the horizontal, or at the angle $2\,b$ with vector $\dot{V}_1$ in the clockwise direction. On this scale, at the required value of $-\,a$, the extremity of the resultant vector $\cosh(a + j\,b) = \dot{V}_0 = \dot{V}_1 + \dot{V}_2$ is found. It may then be read directly from the chart either in the form $A + j\,B$ or $C\,\overline{/\theta}$.

Obviously, the complex hyperbolic cosine may be determined from the same setting by taking the point $\frac{\epsilon^{-a}}{2}$ on the opposite end of the graduated scale along the diameter of the protractor. This is equivalent to reversing vector V_2 as required for the determination of the hyperbolic sine value.


90°
75°
60°
45°
30°
15°
0
S
P
C
2b°
b°
O
x
y
-a
$\frac{\epsilon^{-a}}{2}$
sin h(a+jb)
cos h(a+jb)
Scale giving values of ½ E^-a from C, but marked in values of "a". Scale slides along pin "O".
Polar Chart

Polar-rectangular chart which simplifies transmission line calculations

This device is especially convenient in transmission line problems, since it gives both the hyperbolic sine and cosine at one setting, which values may be directly substituted in the equation:

$$\dot{E}_s = E_r\left(\cosh\dot{\theta}\,1 + \frac{Z_0}{\dot{Z}_r}\sinh\dot{\theta}\,1\right)$$

EXAMPLE

To test the operation of such a chart assume that it be desired to determine $\cosh\left(a + \frac{\pi}{4}\right)$ To do this, convert b to degrees and set scale S at the value 45 deg. Then move scale S along the pin at O until the proper value of a is opposite the pin. Next, turn protractor P through an angle equal to $2b$ (90 deg.) along S, and on the edge at a read the desired value.

The accuracy of the device depends, of course, upon the size of the chart and scales used. Experience shows that an accuracy of three significant figures may be obtained from a chart having an outside diameter of 20 inches.

◆ ◆ ◆

Greater Efficiency for Low-Head Hydro

For heads up to 70 ft. it is predicted that the automatic adjustable-blade feature of the Kaplan propeller-type turbine is capable of producing at least ten per cent more kilowatt-hours.

By George A. Jessop *and* *C. A. Powell*

Chief Engineer,
S. Morgan Smith Co.
York, Pa.
Member A. I. E. E.

General Engineer,
Westinghouse Elec. & Mfg. Co.
East Pittsburgh, Pa.
Member A. I. E. E.

ECONOMY in first costs has stimulated 20 years of effort to secure a higher speed in hydroelectric units; principally because generator costs go down as the speed increases. Until recently an increase in speed has resulted in a reduction of efficiency—particularly at part loads—to a large extent offsetting the advantages of reduced investment. Improvement in generator efficiency with increased speed has only partially offset these reduced turbine efficiencies. Turbine designers now have succeeded in maintaining the maximum or peak efficiency at a given figure over a very wide range of specific speed, and by means of the Kaplan or automatically-adjustable blade runner have improved the part-load efficiency far above that formerly obtained even with slow-speed Francis turbines.

The relationship between specific speed and maximum efficiency is shown in Fig. 1; the specific speed of a runner is the rev. per min. at which a homologous runner will operate under a one-foot head when it is so reduced in size as to develop one horsepower under a one-foot head. Generally speaking, Francis turbines are used up to a specific speed of 110 and the adjustable and fixed-blade propellers for specific speeds above this figure. Fig. 2 shows a comparison between the peak- and part-load efficiency of turbines with specific speeds ranging from 25 to 150. The turbines with specific speeds of 25, 50, 75 and 105 are Francis turbines. Of the two turbines with a specific speed of 150, one is of the fixed-blade and the other of the adjustable-blade axial-flow type. It is interesting to note how the part-load efficiency drops off rapidly as the specific speed is increased—a defect which can be overcome by the use of the adjustable-blade turbine. The notable feature of this latter type is the fact that its efficiency over the entire range of output is high, exceeding even that of the lowest-speed Francis turbine at low loads.

Generator efficiency varies with the load, as shown in Fig. 3 where it may be noted that the efficiency increases with the size of the unit and also with speed. Because of the more marked effect of the windage losses at the higher speeds the part-load efficiency increases less rapidly than the full-load efficiency. Data similar to those given by Figs. 2 and 3 must be combined to obtain the satisfactory performance of the complete unit.

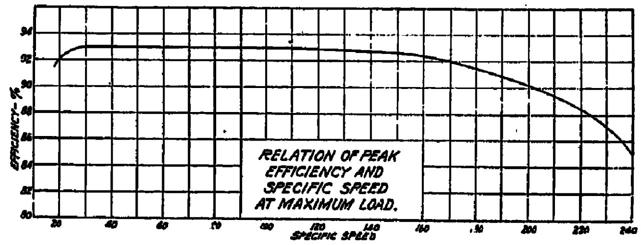


Fig. 1. Relation between specific speed and maximum efficiency

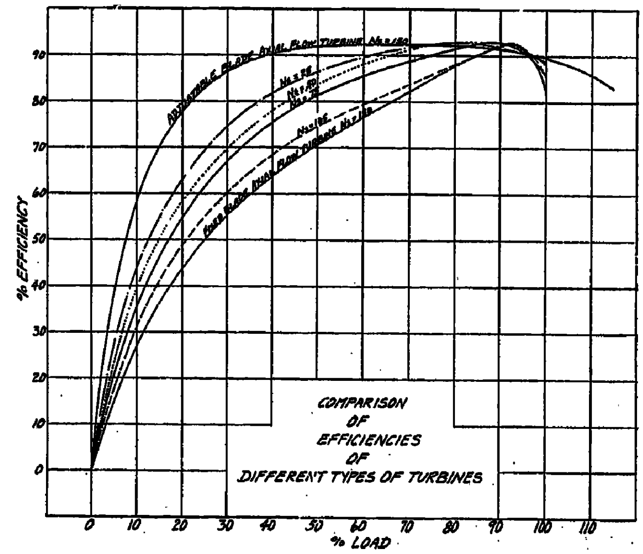


Fig. 2. Turbine load-efficiency curves covering specific speeds ranging from 25 to 150

From "Hydraulic and Electrical Possibilities of High-Speed, Low-Head Developments," presented at th A. I. E. E. Middle Eastern District Meeting, Philadelphia, Oct. 13-15, 1930. (No. 30-165.)

In Fig. 4 is made available a graphical method for determining the allowable relationship between head, horsepower, and speed. The head curves represented by full lines are to be used for Francis turbines, and those represented by dotted lines, for axial flow turbines. At the upper left-hand part of the chart, lines have been drawn indicating approximately the limits of capacity corresponding with the different heads. It is believed that this information will be useful for preliminary engineering work in connection with the designing and estimating of hydroelectric developments and the selection of suitable generator speeds. The limitations of specific speed set by this chart—that is, the combination of horsepower, head, and speed—are the results of many years of experience and at the present state of the art may be regarded as good practise. If plants are designed within these limits and with the proper relationship between the center line of the unit and tailwater, best results in output, economy, and long life are secured.

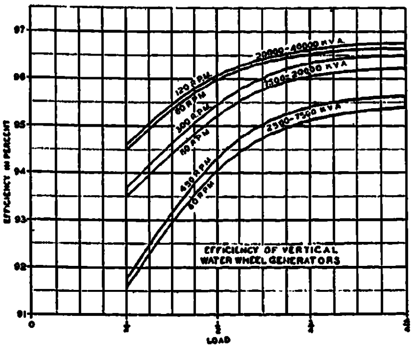


Fig. 3. Generator load-efficiency curves drawn on the basis of normal overspeeds

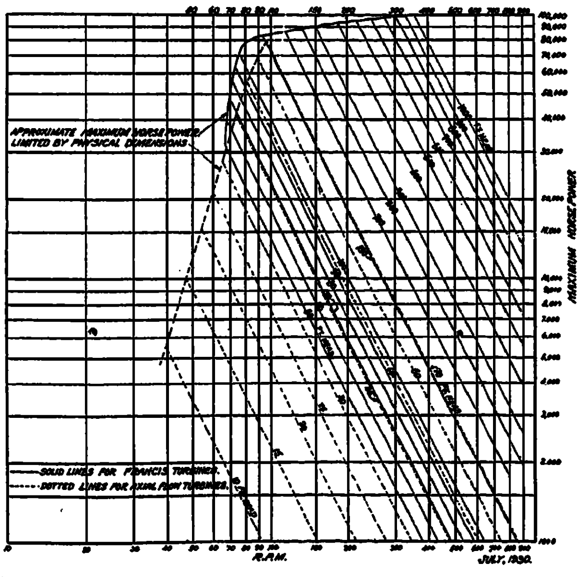


Fig. 4. Chart for graphical determination of allowabl relationship between head, horsepower, and speed

The field of application of the fixed- and adjustable-blade axial-flow turbine lies in relatively low head developments,—approximately 70 ft. or less. One of their great advantages is that they permit considerably higher speeds than the older Francis turbine.

Effects of increased speed on the first cost of the turbine are slight, but there is a definite trend toward reduction. The rev. per min. of a fixed-blade axial-flow turbine may be from 70 to 80 per cent higher than that of a medium-speed Francis turbine, but because the amount of water to be handled is the same in either case the reduction in cost will be approximately only 5 or 10 per cent. The small saving effected is incident to handling the water at somewhat higher velocities. From the generator designers' point of view, there is always an advantage in increasing the speed, because the cost of the generator goes down and the efficiency goes up. (Fig. 5)

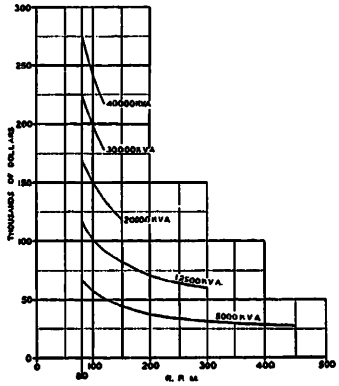


Fig. 5. Generator costs vary with speed and capacity

The cost of an automatically-adjustable turbine is substantially greater than that of a fixed-blade turbine, varying from 20 or 25 per cent for very large sizes to as much as 50 per cent for small sizes. However, this type shows a marked increase in kilowatt-hour output and consequently in earnings; and since the cost of the turbine in most cases is but a small fraction of the whole cost, the total investment is increased only a small percentage.

Excavation and power costs also must be considered in connection with the selection of a turbine. Turbines of high specific speed generally may be set at a lower elevation than those of low specific speed, thus tending to increase excavation cost. This tendency is counterbalanced to some extent by savings in superstructure and it is believed that increased earnings in every case will more than compensate for the greater investment.

As shown in Fig. 6 Kaplan turbine runners resemble a ship's propeller rather than a Francis turbine. Three important Kaplan characteristics are:

1. A vane-free transition space between the discharge area of wicket gates and runner entrance. Water leaving the gates in a whirling inward direction is deflected in this transition space to flow axially through the runner.

2. Wing-shaped runner vanes, so spaced and proportioned that two adjacent vanes form a nozzle or double guidance for part of their radial extent and single guidance for the remainder.

3. Adjustable runner vanes.

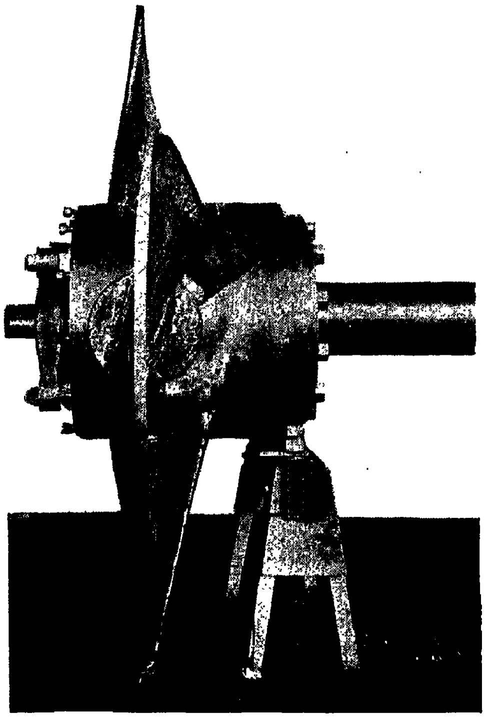


Fig. 6. Axial-flow turbine with adjustable blades open

Professor Kaplan was the first to adjust the runner vanes and the wicket gates simultaneously. This maintains the best conditions of flow throughout the entire range of output and results in high part-load efficiencies, thus securing flat efficiency-load curves. Each position of the runner vanes corresponds to a definite position of the wicket gates, and if the efficiency at all rates of discharge is to be maximum the correct relationship of these positions must be maintained. Since the blade and gate angles and openings always have the correct relationship to each other, the adjustable-blade turbine operates with maximum smoothness and with minimum vibration and pitting. Turbine casings are constructed with the usual wicket-gate casing except that the top plate contains an inverted, curved, cone-like projection which forms the inner surface of the transition-space.

All of the operating connections for moving the vanes are contained inside the single-piece hub casting, (Fig. 7), and are of such form that without any adjustment they will stand up indefinitely under the most severe service requirements. To guarantee freedom from excessive strains and to reduce the possible wear to a minimum, stresses are held within conservative limits. To resist wear, bearings for the runner-blade stems and the links are bushed with bronze, and special provision is made to secure the blades against lateral displacement due to the large centrifugal forces developed. To provide constant lubrication for all moving parts, the hub is filled with a heavy-body oil and each runner-vane trunnion is packed to eliminate oil loss.

To synchronize gate control and runner-vane control, each has its own servo motor and distributing valve. The regulating rod in the hollow turbine shaft is moved axially by a servo motor (Fig. 8) arranged between the flanges of the turbine and generator shafts and rigidly connected to them to revolve with the shaft. The servo motor piston is connected directly to the upper end of the regulating rod which communicates the piston movements to the runner vanes. The servo motor is operated by oil supplied under pressure through two pipes arranged concentrically within the hollow generator shaft. The two pipes terminate in two distributing chambers mounted one above the other on top of the generator. These chambers receive the oil from the governor and collectively form the oil supply head. The governor itself is the usual speed governor which operates the wicket gates either through a vertical gate shaft or through servo motors.

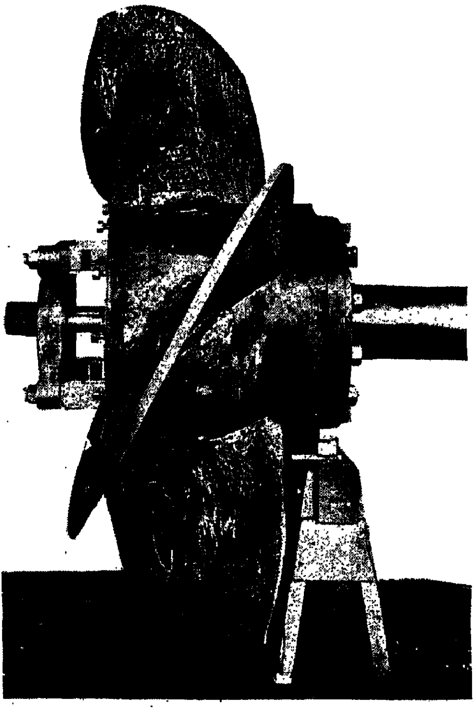


Fig. 7. Axial-flow turbine with adjustable blades closed

The field of application of the umbrella generator is for the large low-head units; and because of its inherent advantages, it is used wherever possible.

To determine the effect of the characteristics of various types of hydroelectric units on yearly plant output, a kilowatt-hour output study is given in Fig. 9. For purposes of illustration, a three-unit development was chosen and a comparison made between three medium-speed Francis units, three fixed-blade axial-flow units and three automatically-adjustable-blade axial-flow units, each rated at 28,500 kw. at extreme full load under a 53-ft. head. The adjustable-blade turbine has a surplus of 15 per cent above the maximum capacity of the other units, and reference to Fig. 2 shows that the adjustable-blade turbine can be selected to have this surplus capacity and still have the part-load efficiency. Even with surplus capacity, the physical dimensions of the adjustable-blade turbine are smaller, and generally speaking, it is possible to operate it at a higher speed than a fixed-blade unit. In Fig. 9 it may be noted that the adjustable unit is operated at 109.1, the fixed-blade unit at 100, and the medium-speed Francis unit at 58 rev. per min. Generator costs for the adjustable units thus will be somewhat less than for the others.

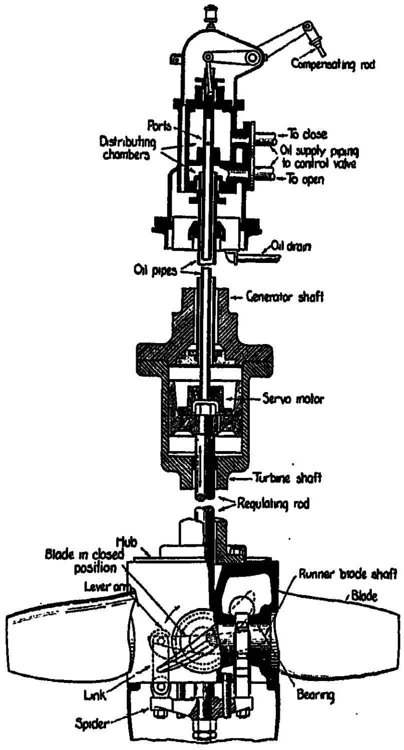


Fig. 8. Assembly and operating scheme of adjustable-blade axial-flow turbine

The kilowatt output was worked up from the head and second-feet available, starting with one unit running, and changing to more units as soon as additional kilowatts can be obtained by so operating. It has been assumed that if desirable from the standpoint of economy in the use of water, each unit can be operated to maximum load and there is no necessity for maintaining a surplus for speed regulation.

It is of particular interest to note that the adjustable units produce 11 per cent more kilowatt-hours than the fixed-blade units and that the Francis and the fixed units have about the same yearly output. If it is necessary to maintain a certain operating reserve, the adjustable units will prove to be even more advantageous than shown, because it will be necessary to operate the Francis and fixed-blade units at even a lower load and consequent lower efficiency for part of the low-flow period. Head and second-foot duration curves are different, of course, for each development and it is necessary to make a special study for each case.

Two types of generators are suitable for use with this turbine; the more general two-bearing design, in which the thrust bearing and one-guide bearing are located above the rotor with the second-guide bearing below the rotor; and the umbrella design in which the single combination thrust-and-guide bearing is located below the rotor. In cost and efficiency there is practically no difference between the two designs, but the umbrella design requires less head room under a crane and is easier to dismantle. Its single bearing runs in a bath of oil, obviating all oil piping, and it lends itself readily to convenient ventilation. If a direct-connected exciter is not used, the upper bracket may be omitted entirely—of advantage in reducing building superstructure.

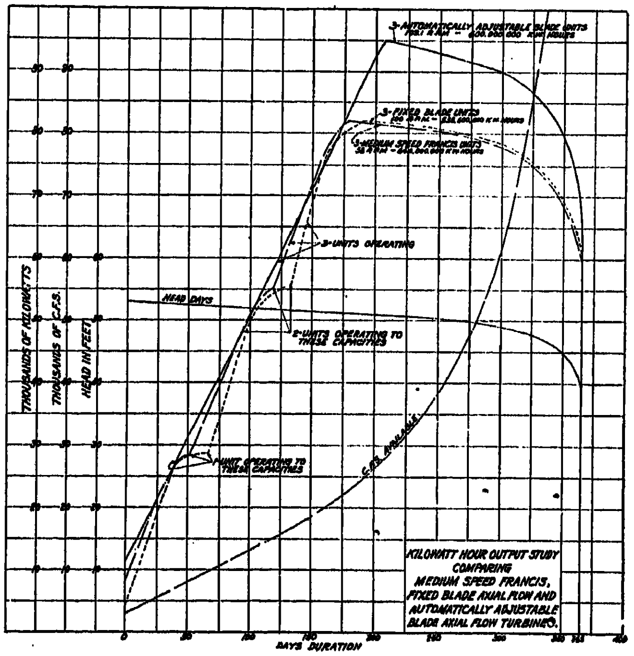


Fig. 9. Output comparison of a three-unit station equipped with three different types of wheels

The field of application of the umbrella generator is for the large low-head units, and because of its inherent advantages, it is used wherever possible.

Detecting Hidden Fissures in Rails

Greater track safety is being accomplished by railroads through the use of a special electrical device which reveals, marks, and classifies dangerous flaws in rails as a test car progresses along the track under test.

By H. C. Drake

Sperry Products, Inc., New York
Associate, A. I. E. E.

"IN THE OLD DAYS" it was not infrequent for flaws in railroad track rails to show up after the wreck. Visual inspections revealed cracks and surface fissures, but hidden fissures—often the most dangerous—remained undetected until the recent perfection of electrical equipment and development of a routine testing technique.

Transverse fissures in rails are fatigue failures of internal origin, whose rate of growth depends largely upon the density of traffic. The typical air-tight fissure has a characteristically bright, silvery appearance produced by the peening action of the fissure faces when the rails are subjected to the impact of heavy wheel loads.

This type of failure was brought to the attention of railway engineers some nineteen years ago when a passenger train was derailed by a rail which broke into seventeen pieces, disclosing a fissure at every fracture. In the years which followed, rail failures due to transverse fissures were reported in ever-increasing numbers. The presence of large transverse fissures in relatively new rails under the best conditions of track maintenance, together with the utter impossibility of seeing or locating such fissures, placed the cause of failure in the class with a cyclone, a lightning stroke, or other "act of God."

In the early part of 1927, internal fissures in rails were successfully detected at the laboratory by the electric method, and after several months of experimental work a fissure-detector car was constructed for the American Railway Engineering Association. The car passed its acceptance test and was placed in testing service on the railroads of the country in November 1928.

For its operation the fissure detector depends upon the fact that electric current flowing through a rail is compelled to pass *around* any fracture, inclusion, or separation in the metal. When a rail is sound the axis of current is substantially straight; but if a fissure is encountered, the current axis at that point is displaced. An inductive pick-up device is mounted directly over the rail head where it cuts the magnetic lines of force surrounding the rail. In the case of a sound rail carrying current, the magnetic flux surrounding the rail is uniform and as the inductive pick-up passes along, no e. m. f. is generated; but when the axis of current is deflected, as at a fissure, the flux density around the rail varies, resulting in a generated potential at the terminals of the pick-up. This output from the pick-up is amplified and led through relays connected to recorder pens, thus giving a record of the impulse received.

In applying the electrical method of fissure detection to inspection of rails in tracking, the following factors materially affect the final design:

1. Many spots are encountered where locomotive drivers have slipped in starting and have gouged out the rail.
2. Worn or flat spots occur frequently, especially opposite rail joints.
3. In certain stretches of track, rail surfaces have acquired a pronounced ripple,—termed corrugated or washboard rail.
4. Frequently the rails are covered with a hard insulating film, the resistance of which may run up to several thousand ohms.
5. The gage of the track varies between certain limits.
6. Rail surfaces may be level or canted.
7. Rail sizes vary from 70 to 130 lb. per yard.

The single-unit type of detector car is 45 ft. long, self-propelled, equipped with extra-heavy frame and axles, and when running to and from work, is capable of a speed of 45 mi. per hour. Just back of the driver's compartment are located the cook's galley and comfortable living quarters for the crew; and back of the living quarters is the compartment containing the power plant of the detector equipment. At the rear of the car is the operating room. The power plant consists of a specially-designed double-commutator, 6,000-ampere, two-volt, d-c. generator direct-connected to a 50-hp. four-cylinder gasoline engine. An exciting generator and an air compressor are driven also by this engine. Current from the two-volt generator is carried by heavy buses to the brush units under either side of the car.

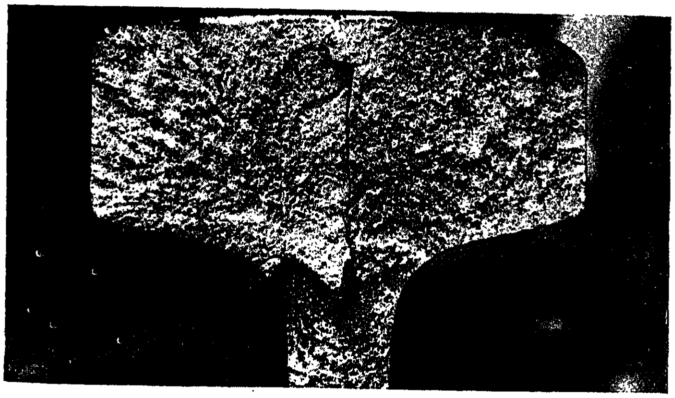
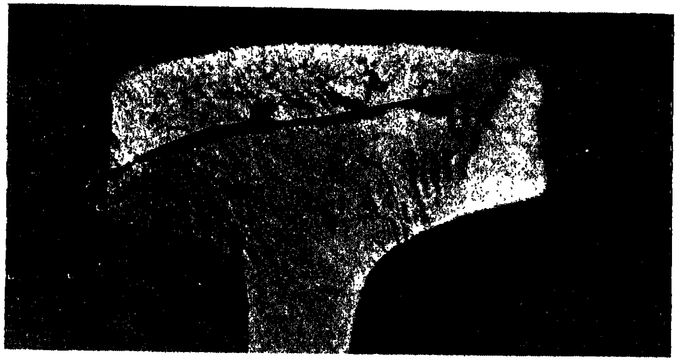
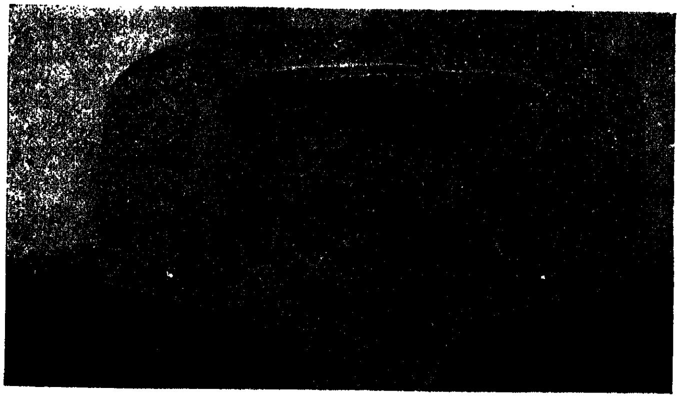
This brush-unit assembly consists of two sets of eight solid phosphor-bronze brushes mounted about three feet apart, rigidly connected by a cast frame, and supplied with individual springs which insure a pressure of 50 lb. per brush. Flanged wheels at the ends of the brush-holder engage the rail when the brushes are down and because of their angular mounting, cling to the gage side regardless of varying track conditions. Brush units are applied to the rail by air-operated pistons electrically controlled from the operator's switchboard. If the driver attempts to back up while they are on the rails, a safety switch connected to the gear shift of the car drive automatically lifts these brushes.

Brush-contact resistance has been found to be greatly reduced by the use of water on the rail; hence provision has been made to carry a sufficient supply of water for this purpose and to apply it automatically to the rail when the brushes are lowered. Mounted

---

Presented at the Winter Convention, New York, Jan. 26-30, 1931. (No. 31-28)

between the brushes is a separate carriage upon which is supported the pick-up unit; this carriage with its eight wheels and swivel mounting holds the pick-up unit at a fixed distance above the rail, riding over burns and flat spots without interruption. At first the driver burns and flat spots gave indications which tended to slow the testing; but that source of trouble was reduced materially by the eight-wheel mounting. Recent improvements in pick-up devices eliminate indications from flat spots and all but the largest of the burns.

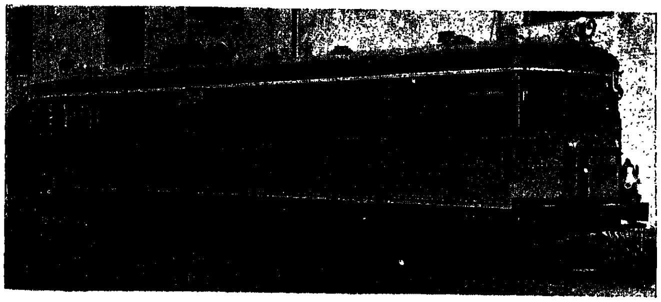




Typical fissures found in railroad track rails; (lower) the internal fissure, (center) a horizontal head fissure, and (upper) a split head. The electrical testing device infallibly locates these under service conditions

The operating room at the rear end of the car contains the recording table and control board as well as amplifying equipment and batteries. The output from the pick-up unit is brought up to a four-tube amplifier which is properly shielded and protected from shock. Three recorder pen relays are connected to the output of the amplifier and adjusted to respond to different values of plate current, thus giving an indication of the size of the defect detected. Other relays are provided to operate paint guns so that the fissure location will be marked automatically by a spot of paint on the rail or tie.

As shown in an accompanying illustration, the record is made up of nine lines, resulting from as many pens, which indicate the relative size of each fissure and the rail in which each is found, the passage of each rail joint, and the passage of each identifying landmark. Joint cut-outs mounted on the brush-holders engage the angle bars and cut out the fissure pens and paint gun at each joint, at the same time operating the joint pens. The landmark pen is operated from the car driver's switchboard. He presses the button whenever a mile post, bridge, signal tower, or other landmark is passed, and the operator at the recording table stamps in the proper designation.

In operation, the car passes along the track at approximately six miles per hour with from 2,000 to 3,000 amperes flowing through each rail, the current value depending upon the weight of rail being tested. The operator seated at the recording table in the rear of the car has before him both the record chart and a clear view of the tested track. When the car passes over a fissure, an indication appears on the record and the defect is marked automatically with a spot of paint. The operator notes the record, sees the paint mark on the rail, stops the car and backs it up to the paint mark for a hand test of the suspected spot. For the hand test a current of 1,500 amperes is induced into the rail by means of air-operated contactors and the unit IR drop is measured with a galvanometer. By means of this test the size of a transverse fissure can be determined within a few per cent.

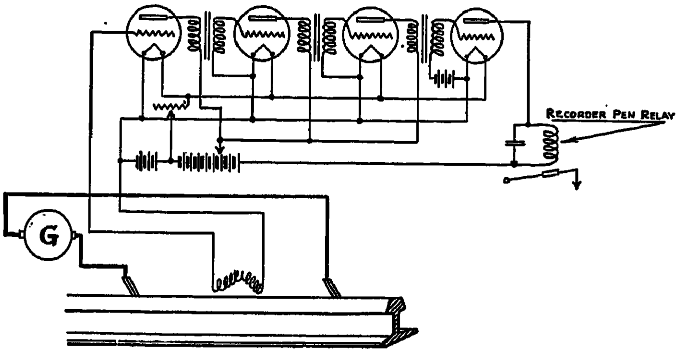


A self-propelled detector car; brush and pick-up units mounted between trucks

The detector car locates not only transverse fissures but split heads, horizontal fissures, compound fissures, pipes, cracked webs, broken bases, and other defects. When a defect is located by the car the first question asked by the railroad representation is, "will it be safe to leave the rail in track until there is a lull in the day's traffic, or must the next train be tied up while the rail is replaced?" The answer to this question lies in the result of the hand test. When the hand test shows no transverse crack the rail is marked for removal at the next opportune time; but if a large transverse fissure is indicated, the railroad takes no chance but removes the rail at once.

Although the testing speed of the car is six miles per hour, there are many elements which enter in to limit the total mileage tested per day:

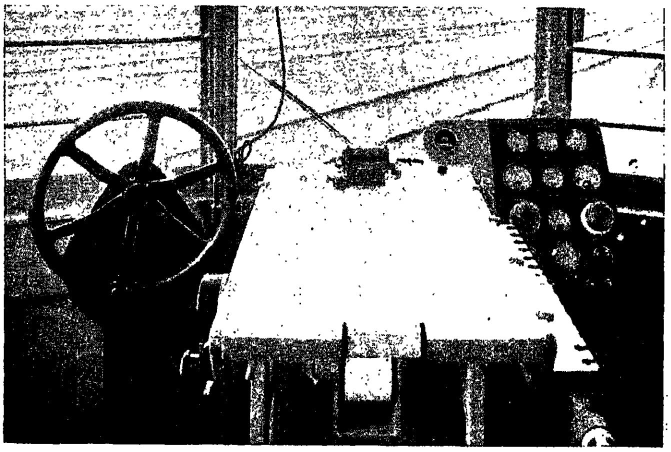
1. Traffic delays due to clearing for trains frequently consume considerable time, but are unavoidable.
2. When a fissure is located the railroad representatives always makes a record of the manufacturer, the year rolled, ingot letter, and heat number of the rail. If the rail has been in track for several years or has been oiled by the track oiler, it is often difficult to locate and decipher the heat numbers and it is not at all uncommon on some roads to have from five to fifteen minutes wasted in obtaining the rail data.
3. A repeat run over a suspected rail takes thirty seconds, and from two to three minutes are necessary for a hand test.



A main bush and pick-up unit; flaws in the rail disturb smoothness of current flow between brush sets, resulting in electromagnetic disturbances which are pick d up by the central device and recorded in the car

Testing procedure on the ten cars now in service is practically identical, but railroads differ somewhat in methods of conducting the test. A survey of the various methods employed indicates that the following procedure results in a minimum loss of time.

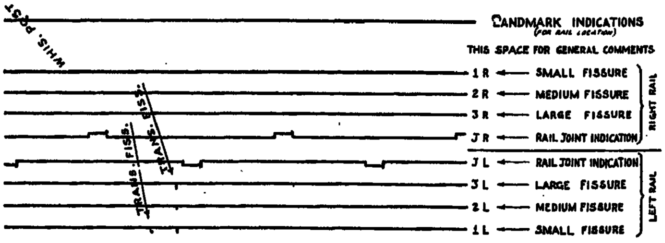
The railroad has one man on the car and one on a hand car which follows the detector car. In addition there is of course a conductor and a flagman. When an indication is recorded the car is stopped, a check run made over the suspected rail, and the car backed up for a hand test. The operator examines the rail and if his visual inspection discloses exterior evidence of a split head, horizontal fissure, or other defect, he gives the word to the railroad man, who makes a red paint mark on the tie at the defective spot and chalks the identification number on the rail. If no visible defect is noted, the hand test is made and the rail is marked as before.



Recording table and control board; the operator can watch the track as well as his instruments

The car then proceeds with the testing while the man on the handcar stops to record all of the data, together with the location of the rail, and then continues on after the test car. In this way the maximum time lost by the major equipment and crew is the two or three minutes required for hand testing.

Two years have passed since the first detector car was placed in service and during that time many interesting fissure facts have been accumulated. A single rail has been found to contain as many as 24 transverse fissures. Fissures have been found in rails 28 years old, and in rails five months old. Many consecutive miles of track have been found to be free of fissures while other short stretches have had from 20 or 30 fissures per mile.



A typical record made by the detector car equipment

While these isolated cases are of interest, the most important point is that the transverse fissures are now being located and removed from track before they can cause damage, whereas prior to two years ago their presence was not even known until they had grown to the surface, or broken the rail.

The Engineer's Duty to Himself and to the Public

The engineer is the one person best qualified to know the vital facts underlying any great project and to interpret their true significance. Upon him, therefore, rests the responsibility of enlightening the general lay public as to the difference between engineering facts and political expediency, particularly where public monies are involved.

By William S. Lee

President, A. I. E. E.

TO DETERMINE the public duty of the engineering profession it is necessary first to understand the engineer's relation to the public. It is an ideal of the Institute that the engineer shall endeavor to assist the public to a fair and correct general understanding of its engineering needs; to ascertain the general knowledge of engineering; and to discourage the appearance of untrue, unfair, or exaggerated statements on engineering subjects in legislation, the press, or elsewhere—especially if these statements may lead to or be made for the purpose of inducing the public to participate in unworthy or unsound enterprises.

When a project of any magnitude is contemplated it is customary to employ engineers familiar with that particular line of work and to submit the problem as a whole to them. After a thorough study of conditions these engineers plan the best layout or design for the project, organize the necessary man power, purchase materials and equipment and ultimately build the project, often organizing the entire operating forces required for its functioning. Thus the engineer is the one person best qualified to know all pertinent details of his project; to evaluate them properly and correctly.

Unfortunately for the public at large, unbiased and fundamental engineering information on major projects seldom is broadcast to the public concerning public or quasi-public projects. In the inevitable financing of any project it is usual that only a few of those involved are well informed. If the project be one in which large numbers of citizens participate in public financing, the engineers' reports seldom if ever penetrate beyond the inner circles, except perhaps in modified form. If the project be one which can be handled with the financial assistance of but a few persons, still only a small group gets a real, direct understanding of the importance of the engineer's position and advice. The result is that great projects are designed, constructed, and put into operation by but few members of the great general public which in the long run pays all the bills.

Consider for a moment those wonderful and enormous projects which you have seen completed by engineering ingenuity in the last two decades. Great organizations and great masses of men and material were mobilized for the purpose by "that army from God knows where."

"No bands were gaily playing,
  When they were going into action;
No crowds were madly cheering
  Their deeds of daring do.
They were owing small allegiance
  To any flag or faction;
Their color was on the sky-line
  And their war-cry put it through."

If the engineer is capable of designing, constructing, and operating these projects, he certainly should be taken into the confidence of the public. His assistance should be invaluable in advising the public as to policy in regard to these developments which play such an important part in the growth and well-being of our country.

It is my wish to emphasize the urgent duty of the engineer not only to convince his brother engineer that his design, construction, and operation are right, but to advise the public to the end that it may be adequately and accurately informed; that it may see the fallacies of half-baked political theories, and may avoid developments that would be prejudicial to the public interest. The American Institute of Electrical Engineers always has emphatically insisted that in all his relations the engineer should be guided by the highest principles of honor. It holds that it is the duty of the engineer to satisfy himself to the best of his ability that the enterprises with which he becomes identified are of legitimate character.

We in America are confronted today with a situation that is fraught with danger, because of the fact that the public may, through partial or insufficient knowledge, reach erroneous conclusions and undertake developments (legislative or otherwise) that would result in our government entering business in competition with its citizens and thus embark upon a course disastrous to the best interests both of those directly affected and of the taxpayers of the country in general. That is why I am urging the engineer, who is trained to consider only facts and absolutely true and complete conditions, to

---

An address delivered before the opening session of the A. I. E. E. winter convention, New York, Jan. 26, 1931.

use his efforts in giving the public the correct picture. An engineer's experience has led him to realize that nothing ever is as good as it appears on first blush and that nothing ever is quite as bad as it first looks. It is the engineer's lot to study a problem with an unbiased mind; to analyze thoroughly and honestly each particular phase of every situation in order to give his client the proper advice. The present national situation is a challenge to the best ability and professional ethics of the engineer—*each engineer*.

President Hoover is fundamentally opposed to governmental industrial ownership and operation. He set this forth very clearly in his concluding remarks in 1924 when, as Secretary of Commerce, he said:

> We are asked to embrace new social ideas, increase our cost of service, decrease our national efficiency, and thus destroy the fundamentals upon which our nation has become great. This is not progressive, for it is not progress. It is destruction.

Ex-president Coolidge in "Calvin Coolidge Says" on January 6, 1931, said in part as follows:

> For wage earners to benefit in time of general depression it would be necessary to assume that government ownership would prevent fluctuations in the business in which it engages. If it is assumed that payment of wages will go on without work, that is not employment, but relief. Then no one should work.
>
> The government has never shown much aptitude for real business. The Congress will not permit it to be conducted by a competent executive, but constantly intervenes. The most free, progressive, and satisfactory method ever devised for the equitable distribution of property is to permit the people to care for themselves by conducting their own business. They have more wisdom than any government.

There are many problems confronting the people of America with regard to public utilities, and especially those utilities that have to do with the generation and distribution of electricity. It is through the engineers I believe that a true and proper study of these problems should and will be made. If the varying tide of sentiment for political or public ownership in this country is based upon correct economic and business principles, the theory should be developed and proved, rather than hurried into existence by retaliatory legislation, an over-persuasive press, or communities that are rightly or wrongly disgruntled.

I cannot refrain from emphasizing the vital necessity of exercising the utmost caution and care in the consideration of these problems. Public ownership in this country and in others, as it has been developed up to this time, by no means has proved that it deserves the support of the people at large; in some instances there have been apparent momenetary advantages, but, in the long run, experience has demonstrated the futility of the arguments of those who favor political or public ownership.

For instance, it has been argued that through the exercise of government financing electric power plants and distribution systems could be constructed with cheaper money. However, it is a well-known fact that construction projects under government supervision generally cost at least twice as much as contruction projects under private ownership, thus eliminating any advantage from this source.

Again, under political or public ownership and operation those properties concerned usually do not pay taxes and the revenue that might be derived from them is of necessity transferred to other sources of taxation. This is a matter of such great public concern that in some states a well-defined movement is under way looking toward the taxing of municipally owned utility enterprises.

In this great country today we are polluted with too much political engineering, political banking, political railroading, and other similar infections too numerous to mention. I think, one of the most dangerous situations that today confronts the engineering fraternity and the public is the mad rush of certain sections to go into political, state, or municipal ownership.

It is the engineer's duty to the public, in these days when there are so many public or quasi-public operations, to make available his judgment and advice so that the people at large may have the advantage of it in arriving at intelligent conclusions in these matters.

It is necessary in this discussion to consider some concrete case: Take the much discussed Muscle Shoals development; why was it built? Does anyone know? Certainly not as a war measure for its actual construction began after the war was over. The nitrate plant located there had constructed a steam plant of a size capable of operating it. This steam plant was within two or three weeks of completion when the Armistice was declared. Why did the government *the next year* begin the construction of Muscle Shoals? I knew and you knew then just as well as we know fifteen years later that it was an unsound venture.

About 1921 the United States government, through its chief of engineers, notified the various power companies and possible power consumers of the South to investigate Muscle Shoals and see if they would be interested in securing power from it through some mutual arrangement. I made a very complete and detailed investigation of this plant, its costs, amounts of power, and other vital points and in a signed report dated May 18, 1921, covering all these matters (a copy of which was sent to the United States Chief of Engineers) my conclusions were given as follows:

> 1. The amount of power estimated by the designing engineer on this work is not correct, nor can it be developed there for practical use. Power cannot be sold as primary power on the basis of average monthly stream flow. Four months' secondary power has no value at present; therefore, the amount of revenu will be materially less than estimated.
>
> 2. Present use of power in the Southern district does not develop more than 50 per cent load factor. The navigation problems incident to this development are such that this plant will have to be run at approximately 100-per cent load factor in low-water season or waste the water.

3. Total cost of this development will be $56,500,000. The additional cost over the present expenditures will be approximately $40,500,000. The plant when completed is not worth $30,000,000.

4. Transmission of power to the systems of the Southern Power Company and the Georgia Railway & Power Company cannot be done in competition with power from other sources.

5. Power transmission to the systems of the Alabama Power Company or the Tennessee Power Company on the same basis as proposed by the designing engineer would cost these companies twice what they can develop their own plants and produce it for.

6. There is no present use or need for this development.

7. The permanent work that has been done should be left as it is, the construction plant salvaged, and the completion of this plant not undertaken until there is developed some use of the power which will require from 80-per cent to 100-per cent load factor.

8. Except for a small amount of power that could be sold to the companies operating near this plant, it would stand idle for years, with no use for the power.

9. The loss in discontinuing this work and waiting until some use for power can be developed will be small as compared to the loss of investing a large amount of money in the plant and letting it stand idle for years.

10. There is no way at the present time that the United States government can get anything approaching a reasonable return on this development if completed.

11. None of the power companies could afford to purchase power under conditions proposed by the designing engineer, and six of the eight could not afford to purchase at any price, because they can develop or procure their power from other sources at a less price than it will cost to transmit the power from Muscle Shoals to their territory.

My reason for discussing Muscle Shoals is the fact that it involves two great principles of the deepest significance to the whole country, industrially and politically:

First, should the government go into business? The more people that work for the government the nearer we approach socialism. I cannot believe that this country is ready to go into socialism; hence why should we be pursuing this policy? The greatest factor in the development of America has been American initiative—and certainly when the government goes out and competes with its citizens in business the great American initiative will be destroyed. Why should a few members of our government persuade the people to set up competition with its citizens when the citizens actually comprise the government? Why should an organization created by the people be endeavoring to destroy the people?

Second, if business is in politics every detail will be the subject of terrific political harangue and investigation.

A review of some of the estimates of cost for Muscle Shoals is startlingly revealing. The development was estimated in April 1920 to cost $23,800,000—say 25 million. Within less than a year this estimate was changed to 50 million; now, the plant has been partially completed and the cost is approximately 47 million and about half of the generating and hydraulic equipment for the powerhouse remains to be completed. A private corporation would have built the same plant for less than half that cost.

For any hydroelectric plant to be successful, be it government or private, it must be able to compete by selling power at a cost equal to or less than that produced elsewhere. Muscle Shoals has less than 100,000 hp. in primary power. In fact, for many weeks during the past year this was less than 65,000 hp. Now, if this plant already has cost approximately 47 million dollars and is still incomplete, it is futile to think of its competing on any kind of a business basis against other sources of power. No doubt many will say that there is a considerable block of secondary power; this is true, but to utilize the secondary power a steam plant must be built, with resultant interest, depreciation, taxes, and part-operating expenses to be provided for. After provision is made for these charges incident to keeping such a steam plant in condition for service, the additional cost of fuel and part-operating expenses with a modern steam plant will be so low that secondary power from Muscle Shoals will not be attractive.

Would any private corporation enter into such a venture? An estimate of approximately 50 million dollars and plant not complete, almost fifteen years since the project began, no contracts made!

There is no doubt that Muscle Shoals has been a colossal political and governmental blunder, but I fear that the next decade will see even greater blunders if some of the projects which are under way now, or projected, are constructed. If Muscle Shoals, begun nearly fifteen years ago, is today earning nothing and has no policy, what will occur at Hoover Dam? There is a tremendous development started, and nobody knows where it is going. An enormous project already started from the funds of the taxpayers, but without tangible evidence of any definite policy or effective contracts. It is time that these matters be discussed honestly and more frankly by the engineering fraternity with the public to obviate the continuance of these terriffic blunders.

Right in the Greater New York area is the greatest aggregation of engineers in the world, and yet serious consideration is being given by the state government to the building of the Long Sault plant on the St. Lawrence River. Every engineer knows that the government costs of constructing that plant will be two or more times what private costs would be. Further, we know that it is impossible to transmit the power from the St. Lawrence River and make it available to the City of New York in competition with modern local steam plants. It looks as if the public is being ballyhooed for another Muscle Shoals, only on even a more gigantic scale.

Engineers have contributed largely to the remarkable progress that has taken place in the electrical field during the past four decades. The progress in this field has been responsible in a very large measure for the wonderful development of industry in America during that period. We engineers are proud and grateful that we have been able to have a hand in the remarkable progress which America has made during these years; and we should be deeply concerned that no obstacle be allowed to slow down or handicap the economic development which means so much to the American people, from the well-to-do down to the humblest working man.

Hence I protest against this dangerous tendency of the day, and I say to each and every one of you engineers, it is your duty, and mine, both to ourselves and to the public, to use our best efforts to see that the public is correctly and properly advised, for when so advised their conclusions will be sound. For,—

'Tis a coward that quits to misfortune,
'Tis a knave that changes each day;
'Tis a fool who wins half the battle,
And then throws all his chances away.
There is little in life but labor,
And tomorrow may find that a dream,
Success is the bride of Endeavor,
And Luck but a meteor's gleam.
The time to succeed is when others,
Discouraged, show traces of tire;
The battle is fought on the home stretch,
And won twixt the flag and the wire.

◆ ◆ ◆

Control Groups Simplify Operation

Unit arrangement, grouping closely around each hydroelectric generating unit all of its associated electric switching and control equipment, accomplishes important economies as well as providing improved operating flexibility and ease of expansion. Radical departures in practise have been combined with others of more usual characteristics to achieve an attractive combination.

By R. M. Stanley and *E. D. Wood*

Byllesby Engineering & Management Corporation
Chicago
Fellow, A. I. E. E.

Louisville Gas & Electric Company
Louisville, Ky.
Member, A. I. E. E.

ELECTRICAL features constituting the control of the Ohio Falls hydroelectric station of the Louisville Gas & Electric Company represent a distinct advance in the art of utilizing well established principles combined in a unique fashion. Thus an initial installation cost lower than usual has been achieved as well as basic provision for extensions which can be made in a most economical fashion from time to time. The design of the station is particularly unique in the fact that each generating unit is complete in itself; water-wheel, generator, exciter, governor, electrical control, and oil circuit breakers are individual to each generating unit, and all related unit auxiliaries are fed entirely from that unit, with but few exceptions. The four points that are retained in common and which reflect the more usual design are (1) forebay, (2) high-voltage buses, and (3) centralized coordinating control for the station.

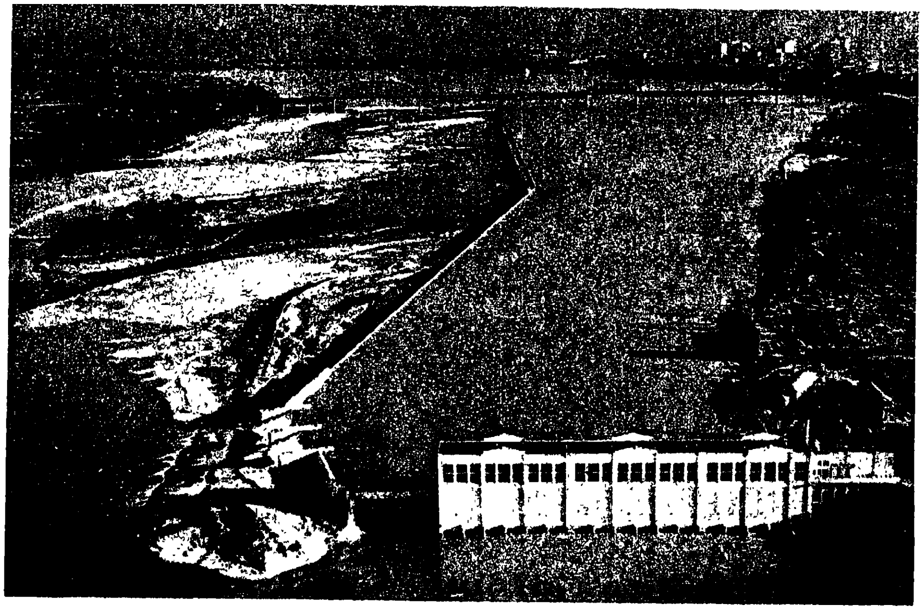
Each of these features may of course be recognized as embodying well established principles, but the prominent characteristic of the Ohio Falls station lies in the fact that in it are utilized simultaneously, all of these combined to the best advantage. The design is characteristic of simplicity, practically all conduit and wiring as usually encountered having been completely eliminated.

One of the basic ideas was an electrical control unit corresponding to the hydraulic control unit, situated near each generating unit. This feature has been accomplished by grouping all of the electrical control features and placing them inside a cubicle located just adjacent to the governor. But while this concentration of electric and hydraulic control is particularly desirable as far as installation is concerned, it did not seem to solve the problem of economical operation. Therefore a centralized supervisory control was incorporated, with a single multi-conductor telephone cable between it and each generator control unit. This arrangement happily accomplished centralized supervision and control of all units, at the same time reducing to a minimum the number of wire connections between the central control point and the controlled cubicle.

Because of the lower inspection and maintenance expense, operating as well as fixed costs are reduced. Substitution of the miniature switchboard and low-voltage, multi-conductor, lead-covered control cable for the usual large central control board and 19/22 control cable and iron conduit is principally responsible for this improvement. Further saving was realized in

---

From "The Ohio Falls Hydroelectric Station at Louisville, Ky." (No. 30-188) presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.



Ohio Falls hydroelectric plant of the Louisville (Ky.) Gas & Electric Company; City of Louisville in the background. This project was built in cooperation with the U. S. Government in connection with its navigation and flood-control development of the Ohio River

obviating the cost of building, heating, and maintaining a control room of the usual proportions and location.

As new 4-, 13.2-, 66-, or 132-kv. feeders and related switching equipment may be required, they can be installed in the yard adjacent to the plant and unit-type switchboards, either singly or in groups, may be placed near the equipment to be controlled. To provide supervision for the new equipment the miniature switchboard can be extended four inches at a time to accommodate low-voltage multi-conductor cable installed as needed between the miniature board and the unit switchboard at the apparatus; and since the original plant layout need not be disturbed, this may be done at a minimum cost. Another important benefit realized in this station is that such extensions and additions do not involve the danger of work around operating equipment; the hydro station will not be cluttered with construction tools and debris; and station operation will not be jeopardized by work being done on control wiring and conduits located near active equipment, as was customary under the old order of things.

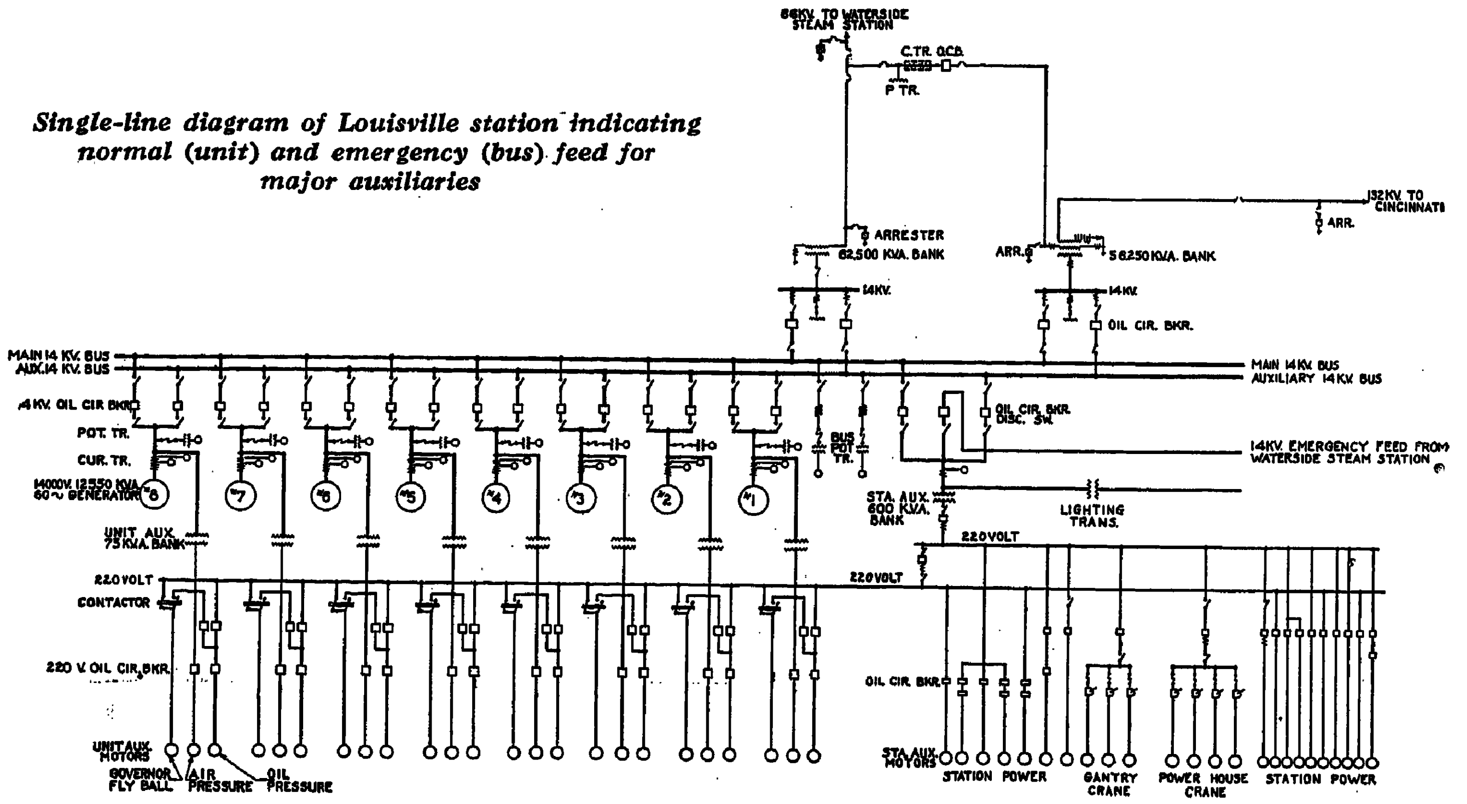
Three years of successful operation of the original plant, with successful installation and operation of later important additions, have demonstrated conclusively the entire justification of the departure from conventional layouts. It has been proved that the miniature switchboard accomplishes in a successful manner the centralized control and supervision of equipments widely separated physically. This has been done with minimum space and cost and in such a way that future requirements may be met in an economical manner as they develop and with no capital outlay in advance of the actual operating requirements.

Water supply for the Louisville plant comes through the Ohio River from a 91,000-sq. mi. area extending well into New York, Pennsylvania, Virginia, and Maryland. Conditions are such that the natural flow of the river varies from about 792,000 sec.-ft. at the time of maximum flood to 5,000 sec.-ft. or less during summer drought; whereas the present total water capacity of the plant is 32,000 sec.-ft. The 8,680-ft. dam, which was built in connection with the U. S. government's Ohio River canalization plan, is the longest and highest dam on the Ohio River. Together with the natural fall of some 28 ft. in the river bed at Louisville, a maximum operating head of 37 ft. is provided.

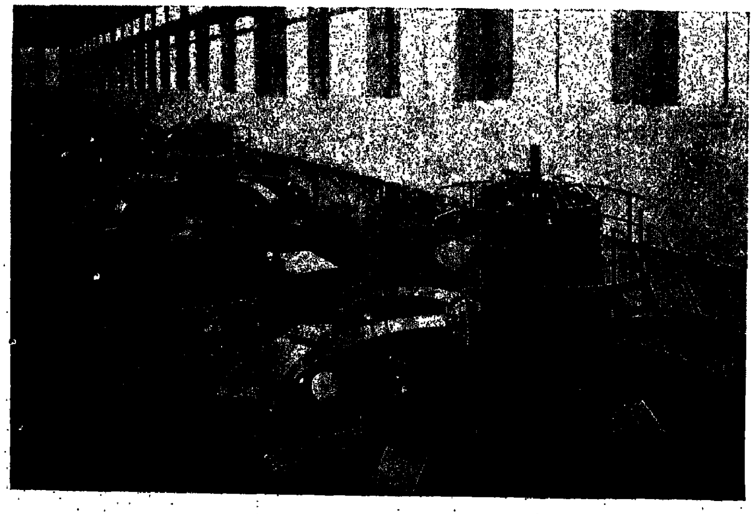
The water-level variation had much to do with the design of the station; to save in superstructure, the generator room floor is depressed 16 ft. below the entrance level which is 4 ft. above maximum high water, and water-wheels are placed near the low-water level. At present eight 13,500-hp. units (at 37-ft. head), are installed and provision is made for two additional units. Because of their ability to operate under heads varying from the maximum of 37 ft. down to 8 ft. five-blade propeller-type, axial-flow runners, designed to produce 13,500 hp. at 37 ft. net effective head at a speed of 100 rev. per min., were selected.

The 15-ft., 20-ton, cast-steel runner is connected to the rotor of the generator by 61 ft. of 23-in. shaft, the 125-ton combined weight of the assembly being suspended from a spring-type thrust bearing. Because of the long shaft four guide bearings, three of babbitt and one of lignum vitae, are used. Electrically driven fly-ball governors operated automatically provide positive control to servo motors and guide-vane latches, the latter being mounted directly on the cover plate to eliminate strains on the shift ring.

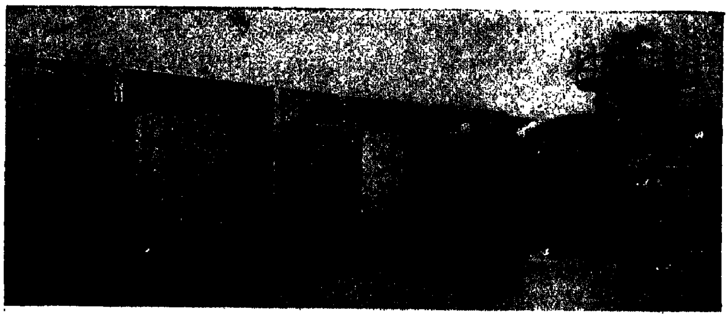
Single-line diagram of Louisville station indicating normal (unit) and emergency (bus) feed for major auxiliaries



Each generator is rated at 12,550 kv-a., 14 kv. at 100 rev. per min. and equipped with direct-connected exciters mounted on the thrust-bearing housing. From the armature winding twelve leads are brought out to a terminal board to permit differential protection, and also for the purpose of changing the operating characteristics as desired. Normally for full-load operation the windings are connected two-circuit Y but for light loads they may be connected one-circuit delta. Improved efficiency of the delta connection as compared with the Y connection is computed to vary from 2.1 per cent at 10 per cent of full load to 0.5 per cent at 75 per cent of full load, 0.9 power factor. Above 75 per cent of full load the Y connection is used and normal efficiencies are obtained. Generator ventilation and cooling is accomplished through a totally enclosed system and all leakage air is made up through air filters to remove dust and dirt. The continuing clean condition of armature and field coils resulting from this ventilation system has kept the efficiency of the units at the original value.

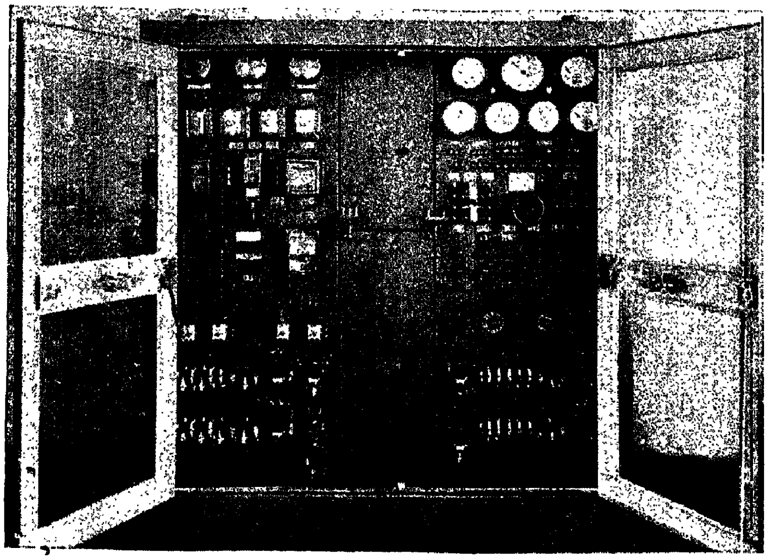


Generator room of the Louisville plant showing the present eight 12,550-kv-a. generating units, each with its immediately associated switching and control equipment. Buses run the length of the power house in the sheet-steel enclosure along the upstream wall, back of the generators



One of the unit groups; (from the right) generator, hydraulic governor, supervised control and regulating cubicle, and two oil circuit breakers

Manual and automatic control of the generators, outgoing lines, and station service banks is performed by means of standard panels and control equipment located in close proximity to the equipment controlled. For

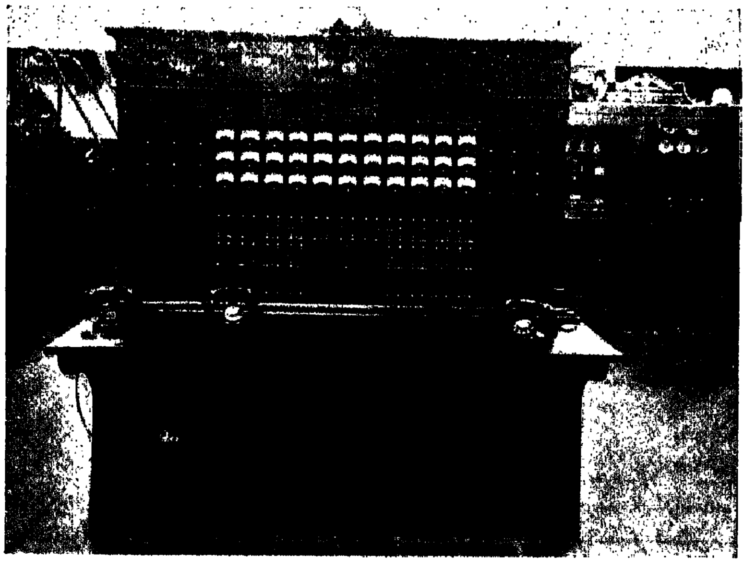


Interior (front) of a generator cubicle which contains instruments for both manual and automatic control of its generating unit. Pull-button switches on doors and floor-attendant signal lights on top of cabinet may be noted also

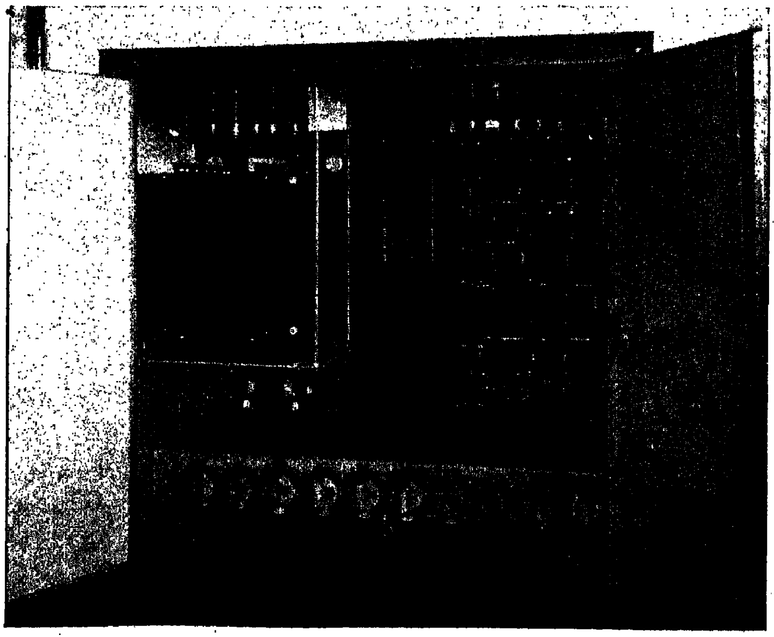
protection of th control equipment these switchboards with associated relays, contactors, etc., are mounted in sheet steel housings. Both control and meter circuits are brought to the switchboards by means of Greenfield cable through multi-circuit train-type couplers. These couplers facilitate maintenance and greatly expedite quick and complete isolation of the board.

Each hydroelectric generating unit is designed as a complete station within itself with its individual auxiliaries automatically and independently operated. Realizing that auxiliary failures mean jeopardized service, several additional features were included to insure dependable operation. The scheme of unit auxiliary equipment also is carried out as regards electrical equipment, in that all of the auxiliaries with the exception of compressed air for the brakes and the d-c. control voltage are fed directly from each generating unit.

During the starting period, the governor fly-ball and oil-pressure-pump motors are fed from a 230-volt station auxiliary bus. As the generator comes up to speed and 85 per cent of normal voltage is reached the governor fly-ball motor is transferred automatically to the unit feed. The governor oil-pressure motor is transferred manually from the station feed to the unit feed. The generator cooling-water pump motor is fed directly from the unit transformer bank at all times; as previously mentioned, excitation for the generator is from direct-connected exciters.



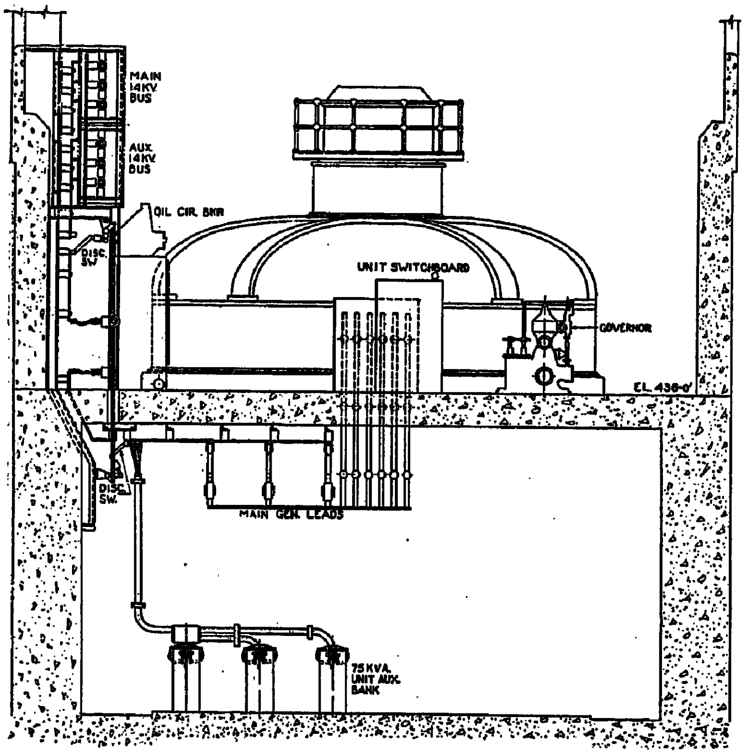
Central supervisory board with its four-inch panels



Rear of generator cubicle; train-type multi-circuit couplers expedite maintenanc

The miniature switchboard used to provide centralized control of the operations of the station is centrally located on the generator floor between units Nos. 4 and 5. The control equipment consists of a two-position control key for each circuit breaker or other device controlled, together with the usual red, green, and white signal lamps. In addition to the supervisory control keys the miniature board contains voltmeters, reactive volt-ampere meters, wattmeters, switches for raising and lowering load, and switches for regulating voltage. Control and meter circuits are taken from the supervisory panels by means of low-voltage telephone wires to a terminal box beneath the generator room floor. From that terminal box to an auxiliary terminal box near the unit switchboards lead-covered 16-pair telephone cable in rigid conduit is used, there being one such cable between the supervisory panels and each generator, transformer bank, and station auxiliary switchboard unit. Insulating, potential, and current transformers protect the small instruments on the supervisory board.

In the operation of the control equipment the operator at the supervisory panel selects by turning his bus selector key the bus to which the machine is to be synchronized giving the starting signal to the floor attendant by turning the "start and stop" control key to the "start" position; he also selects whether automatic or self-synchronizing is to be used in each particular instance. The floor attendant then checks to see that the gate limit stop is set for full-speed no-load value of head, and closes a pull-button control switch on the door of the generator cubicle to give the actual starting impulse to the unit. The usual assembly of protective and interlock devices prevents improper sequence in the operation and serves to shut down all related equipment when something goes wrong.

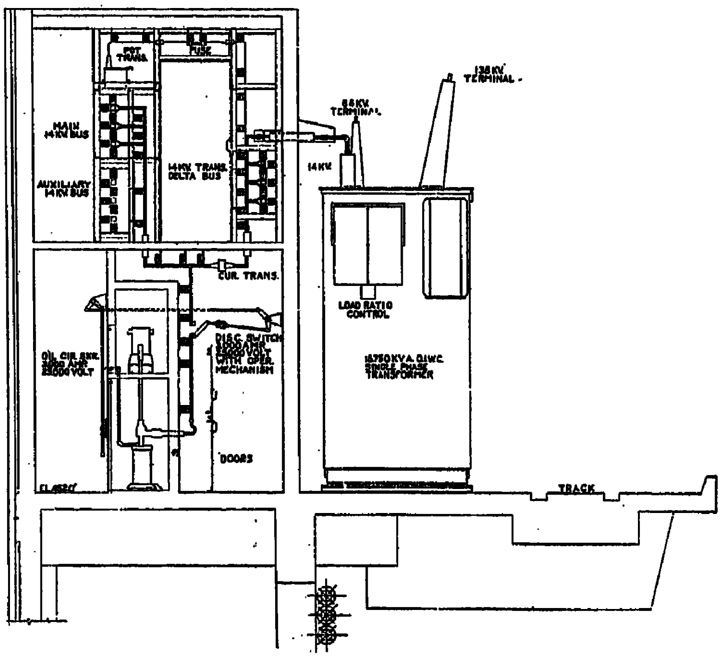


Generator leads are simplified with the unit grouping; main and auxiliary buses extend the length of the station

Operation of the Ohio Falls station depends entirely upon the flow of the river. Low water and small volume or the rapid and excessive rise of tailwater under flood conditions because of restrictions in the channel downstream, result in a curtailment of power output. The average yearly complete shutdown due to high water is 45 days. To meet navigation requirements the forebay pool is maintained as nearly constant as possible at El. 420, thus necessitating plant operation at the highest point of efficiency during low-water periods, at which time the plant operation is the governing factor of the pool stage. To meet emergencies for short periods all available equipment can be put into service within two minutes. Of course during periods when the flow exceeds the discharge capacity of the station, efficiencies are disregarded, and pool stages are controlled by a combination of manipulation of dams and plant operation.

Appreciable savings both in time and in labor costs in operating this plant have been realized as a result of the use of automatic control equipment. Only one switchboard operator is required on a shift, and where five floor men per shift would have been required for the eight generating units under other conditions, in this station only three are required.

Maintenance costs on the station have been even lower than were at first expected, which has given rise to the belief that the use of automatic equipment has resulted in less rather than in more maintenance. Experience shows that with the equipment once properly adjusted, the routine tests and inspection have been the smallest maintenance item. These tests are conducted weekly and require only the part time of one maintenance electrician.



Main transformer connections also are simplified

The miniature switchboard is expected to permit further economies and may even be removed to a future nearby steam station in which case one operator can control both stations.

Magnetic Circuit Units Adopted by I. E. C.

Standardized designations already adopted will obviate confusion if generally ratified; further international standardization of electromagnetic nomenclature is urged.

By Arthur E. Kennelly

Professor Emeritus of Electrical Engineering
Harvard University, Cambridge, Mass.
Fellow A. I. E. E.

AT a plenary meeting of the International Electrotechnical Commission (I. E. C.) held in Scandinavia in the summer of 1930 was conducted a series of international committee meetings on the subject of electric and magnetic units. Agenda for that series of meetings had been prepared and distributed internationally many months in advance. In America a subcommittee on magnetic units of the U. S. national committee of the I. E. C. had held a number of meetings in New York, had prepared duly approved agenda for Scandinavia, and had distributed the same among the other national committees abroad.

Ever since the electrical congress at Paris adopted the C. G. S. magnetic units *maxwell* and *gauss* in 1900, there has been a growing confusion in international electrotechnical literature as to the proper use of the unit *gauss*. Some writers used the *gauss* as the unit for magnetizing force $\mathcal{H}$, others used it for magnetic flux density $\mathcal{B}$, and still others used the *gauss* for both $\mathcal{H}$ and $\mathcal{B}$ indiscriminately. This vagueness and lack of uniformity was not confined to the literature of any single country; it was found in that of all or nearly all countries and the confusion may be said to have become universal. There was, however, universal agreement upon the internationally accepted equation

$$\mathcal{B} = \mu \mathcal{H} \qquad (1)$$

where $\mathcal{B}$ is the flux density in a magnetizable medium, $\mathcal{H}$ the magnetizing force, and μ the permeability of the medium. In the case of a vacuum, or free space—*i. e.*, non-magnetic material—the same equation becomes

$$\mathcal{B} = \mu_0 \mathcal{H} \quad \text{gausses} \qquad (2)$$

where μ_0 is the permeability of free space, which admittedly is equal numerically to unity in the C. G. S. magnetic system.

In equation (2), if space permeability μ_0 is a mere number unity, then both $\mathcal{B}$ and $\mathcal{H}$ are expressible in *gausses*; but if μ_0 has physical dimensions and is not a mere unit number, then $\mathcal{B}$ is expressible in *gausses* but $\mathcal{H}$ is different, and is expressible in some other unit.

The I. E. C. Scandinavian meeting decided unanimously in favor of the electrotechnical convention that μ and μ_0 are physical quantities and not mere numerics, and that $\mathcal{B}$ only should be expressed in *gausses*. For the expression of $\mathcal{H}$, a new unit name was adopted; namely, the *oersted*. In fact, Oersted was the Danish physicist who discovered at Copenhagen in 1820 the experimental fact, previously unsuspected, that a wire carrying an electric current exercises a deflecting magneto-mechanical torque or couple upon the poles of a suspended magnetic needle.

After reviewing the I. E. C. decisions on magnetic units as made at Oslo, recommendations for future consideration and discussion are made as follows:

(1) The I. E. C. decisions at Oslo to be ratified and generally adopted, thus eliminating confusion among magnetic units in the future.

(2) Another C. G. S. magnetic unit for reluctance might advantageously be adopted in the future. In America the *oersted* was used very generally as the unit of magnetic reluctance, but this had never been adopted internationally and the assignment of the *oersted* to magnetizing force $\mathcal{H}$ leaves a gap in the series of units expressing magnetic Ohm's law.

(3) A series of magnetic units in the practical or *volt-ampere-ohm* system might advantageously be considered in the future, commencing with the *pramaxwell* adopted at Oslo; but that before attempting any further international action on practical magnetic units, certain preliminary questions as to rationalization and also the particular system to be adopted, should first be studied, formulated, and internationally settled. This necessarily will take time.

From "Magnetic-Circuit Units as Adopted by the International Electrotechnical Commission" (No. 31-7) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

◆ ◆ ◆

Electric Welding Advances in Modern Building Construction

CONSIDERING the new field arc-welded fourteen-story office building of the Edison Electric Illuminating Company (Boston) and a nineteen-story all-welded structure in Dallas, Texas, a few of the data on the Boston job as given by Frank P. McKibben in the *G. E. Review* (Dec. 1930) may be of something more than passing interest.

A combination of shop riveting and field welding effected the best use of facilities available. Steel erection was begun April 9, 1930, followed by the welding beginning on April 28, completion of erection June 26, and completion of welding June 27. Four welding machines were used and seven welders chosen by competitive tests of their work. Of a total of 1,314 tons of structural steel in the structure, 1,050 tons were electrically welded with 2,080 lb. (net) of electrode in 1,205½ man-hours of labor and 6,120 kw-hr. of electric energy. Filet per ton of steel welded amounted to 57.63 in. with 50.2 in. deposited per welding man-hour. Filet deposited per eight-hour day amounted to 402 in.; per pound of wire melted, 29.09 in.; and per kw-hr., 9.9 in. Electric energy required per ton of building steel amounted to 4.66 kw-hr.; per ton of welded steel, 5.83 kw-hr.

Inspection service included, (1) qualification and periodic tests of welders, (2) ascertaining the use of proper electrodes and current values, and (3) in verifying completed welds as to quality and as to size, length, and location in accordance with plans. A complete daily log was kept.

◆ ◆ ◆

The Oil-Blast Circuit Breaker

A further development of the explosion-chamber principle avoids the mixing of arc and oil in the main gap, utilizing the high oil pressure together with smooth and controlled flow of oil from the chamber to sweep away the arc, replacing it with a stream of clean oil. With this design tests show that a voltage of 44 kv. per inch across the working gap actually is reached.

By D. C. Prince *and* *W. F. Skeats*
Fellow A. I. E. E. Associate A. I. E. E.
Both of the General Electric Company, Schenectady

FOR MORE than thirty-five years the oil circuit breaker has been used as an interrupter for a-c. circuits and it still is the most practical, economical, and effective device so far developed for that purpose. In recent years much study has been given to the determination of the fundamental characteristics of the arc in oil as encountered in oil circuit breakers. One of the first important facts brought to light by these studies was that an unconfined arc in oil is extremely erratic in length, duration, and amount of gas formed. Even the maximum arc lengths vary in different sizes of breakers at the same currents and voltages, and in the same breaker are different with various opening speeds. These maximum values for various conditions and voltages have been determined from actual tests and are used as the design basis in plain-break breakers.

An excellent analysis of oil circuit breaker phenomena explaining the qualitative factors governing deionization rates in arcs, is to be found in the A. I. E. E. TRANSACTIONS, Vol. 49, 1930, pp. 421-446 ("Extinction of a Long A-C. Arc," by J. Slepian, and "The Use of Oil in Arc Rupture," by B. P. Baker and H. M. Wilcox.) The principle of confining the arc and maintaining a supply of oil in its immediate vicinity has been confirmed, although the means suggested differ considerably in operation from the method employed in the explosion chamber. The importance of low dissipation of energy in the arc in keeping down the mechanical stresses accompanying an interruption has been set forth, and a new structure has been developed for the purpose of accelerating the deionization of a mixed gas-and-oil arc path, so as to raise its dielectric strength during the short interval while the restoration of voltage across the breaker contacts is taking place. The deionization processes suggested, however, operate vigorously throughout the current cycle, requiring for an arc of given length, high voltage and energy dissipation and causing, therefore, a rapid evolution of gas. This is unavoidable where effective deionization at the current zero must be secured in a fairly homogeneous arc path. But the arc path at the time of rupture need not be homogeneous and it is the purpose of this paper to describe a process operating along entirely different lines.

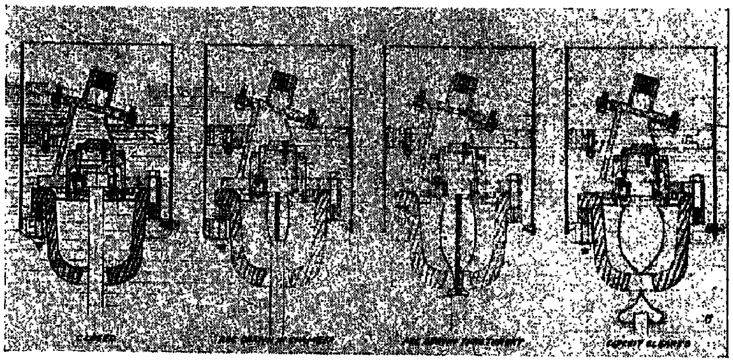


Fig. 1. Four successive stages in the operation of an ordinary explosion chamber

For existing circuit breakers the arc path at the time of rupture has an effective dielectric strength of from about 2.5 kv. per in. in plain-break circuit breakers up to 10.0 kv. for the deion-grid breaker, and as high as 15.0 kv. for standard explosion-chamber circuit breakers. Clean oil has a dielectric strength of over

---

From "The Oil-Blast Circuit Breaker" (No. 31-5) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

200.0 kv. per in., with a strength under impulse over 600.0 kv. per in. The introduction of any considerable amount of solid oil into the gap at the current zero therefore holds possibilities of great improvement over other methods of interruption.

Under the worst conditions line voltage may be impressed across a 15-kv. breaker in 10 microseconds. The rate of voltage rise is then $\sqrt{2} \times 1.5 \times 10^9$ volts per sec. Assuming the oil to have the dielectric strength it presents to impulse voltages, or about $\sqrt{2} \times 6 \times 10^9$ volts per in., fresh dielectric must be introduced at the rate of 200 ft. per sec. This velocity corresponds to a pressure of 255 lb. per sq. in., which is not an unusual explosion-chamber pressure.

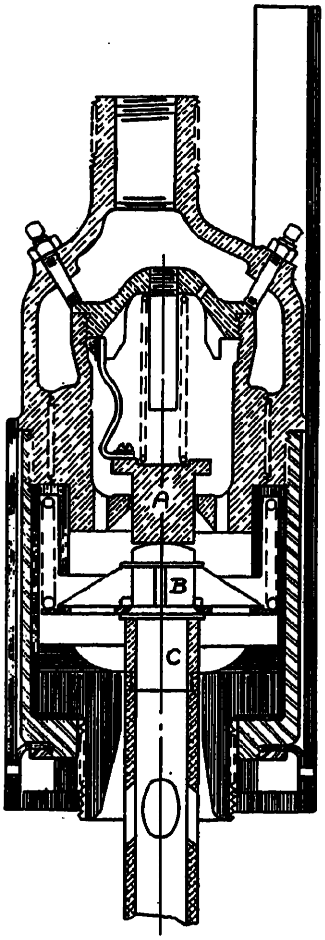


Fig. 2. Explosion chamber specially designed to utilize more effectively the kinetic energy of escaping oil to cut the arc

A high-voltage transformer will have a recovery rate corresponding to $\sqrt{2} \times 5 \times 10^9$ volts per sec. while the rate for a long-distance 220-kv. transmission line will be about $\sqrt{2} \times 0.8 \times 10^9$ volts per sec. even though the full voltage corresponds to 220 kv., line-to-line. It is quite possible to design a circuit breaker so that oil will sweep away the arc at the rate required by the foregoing calculations.

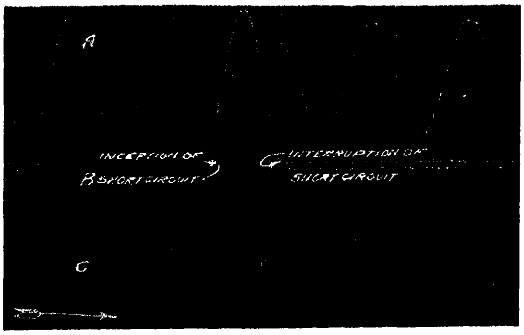


Fig. 3. Oscillogram of interruption of 24,800 amperes at 13.2 kv., 24 cycles, by an oil-blast breaker; (A) voltage across contacts; (B) line current; (C) tank pressure

Effectiveness of the explosion-chamber breaker may be explained in this way. Fig. 1 shows a standard high-speed explosion-chamber circuit breaker in four positions. In the first diagram the breaker is shown in the closed position; in the second, the contacts have separated and a small arc has been drawn which has decomposed sufficient oil to place the remaining oil in the explosion chamber under considerable pressure; in the third diagram, the moving contacts have reached the explosion-chamber throat and oil is being crowded in upon the arc in the throat; in the fourth diagram the

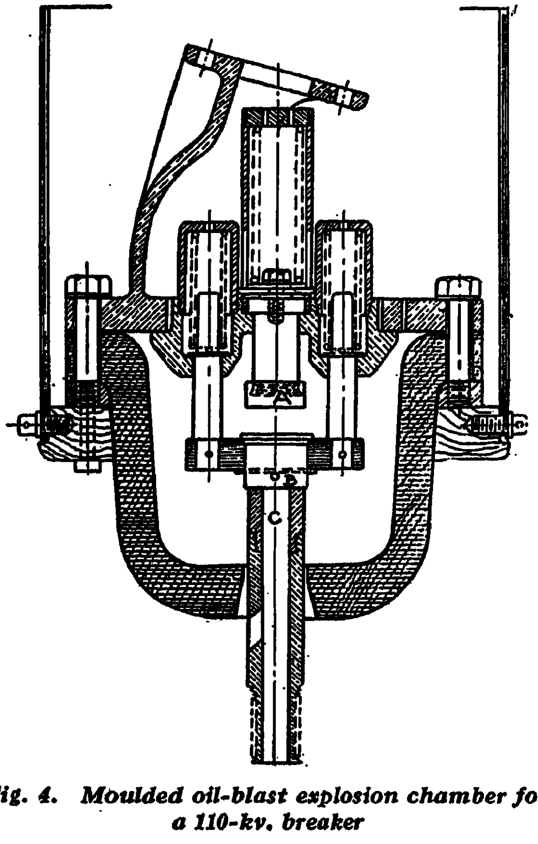


Fig. 4. Moulded oil-blast explosion chamber for a 110-kv. breaker

oil has divided the gas bubble into two parts, interposing a solid wall between them, and thus effectively opening the circuit.

As the gas bubble expands, driving the oil through the throat of the explosion chamber, the pressure varies from hundreds of pounds in the large part of the volume of the explosion chamber to a very low value actually in the throat; that is, the potential energy of pressure has been converted into kinetic energy of velocity. At the same time, since the pressure is low in the throat, the oil can very easily rush into this space so as to cut the arc in two.

TABLE I—TESTS OF 110 KV., 600 AMPERE OIL-BLAST CIRCUIT BREAKER

Feb. 6, 7 & 18, 1930

Voltage	Amperes	Arc duration Cycles	In. per break	Kv. per in.
22 kv.	1530–1880	0.8–2.2	0.8–2.6	4.2–13.7
44 "	3240–5000	0.5–1.5	0.5–1.7	13–44

To make this action even more positive the form of explosion chamber shown in Fig. 2 has been developed. It contains an upper butt contact *A*, a floating contact *B*, and a hollow contact *C*. When the breaker is tripped, the floating and hollow contacts, *B* and *C*, start down, driven by the opening springs, thus drawing a short arc between *A* and *B*. This arc forms gas and places the oil in the explosion chamber under pressure for which there is little relief until the floating contact reaches its stop. The secondary break and arc then occurs between contacts *B* and *C*; however, as the oil glides through the passageway in the contact rod, this arc is carried before it and exists alongside of it without mixing—hence with a minimum loss throughout the current cycle. Then, as soon as the current zero is reached, the arc products are displaced by a smoothly flowing wall of solid oil, the dielectric strength of which has not been impaired by carbonization or entrained ionized gas.

Several beneficial effects are obtained by the use of this modification: In the first place, the necessary arc length at generator voltages is reduced from something slightly in excess of the inside length of the explosion chamber to a little more than one inch per break. With a given contact speed this shorter arc can be established more rapidly—of decided advantage in cutting down the duration of short circuit and the arc-energy dissipation. The importance of reducing the energy from the points of view of (1) keeping down the mechanical stresses and oil deterioration resulting from a given interruption, (2) increasing the interrupting capacity of a structure of given size, and (3) minimizing the demonstration accompanying an interruption—has been previously established. In addition, the shorter arc duration results in less burning and longer life of the contact parts and of the oil. Also, both arcs are quite effectively kept away from insulating material so that burning of insulating parts is reduced. These two latter effects operate to cut down inspection and replacement requirements. Finally, the oil is more effectively directed into the second gap, so that the current range over which the chamber operates effectively is increased.

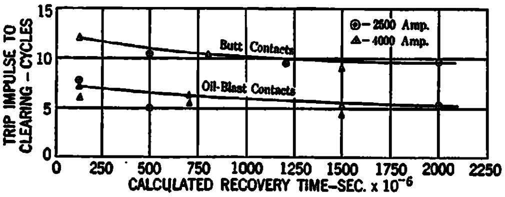


Fig. 5. Results of service tests of a 600-ampere 132-kv. oil-blast breaker

More than 250 tests have been made with currents from 900 to 25,600 amperes at 13.2 kv. and up to 56,400 amperes at lower voltages. Above 5,000 amperes the arc is uniformly extinguished at the first current zero occurring after the secondary contacts have been separated by as much as an inch; and in many cases the arc has been extinguished with a contact separation of but a quarter of an inch. Fig. 3 is a typical oscillogram showing the operation of this circuit breaker.

The need for high speed of interruption is fully as urgent at transmission voltages as at generator voltages. Accordingly, a somewhat larger explosion chamber was modified to correspond to Fig. 2. This arrangement was found to be effective up to 44 kv., as is demonstrated by the data in Table I. By comparison with the performance of the standard explosion-chamber breaker, the data shown in this table indicate consider-

TABLE II—TESTS OF 110-KV. 600-AMPERE OIL-BLAST CIRCUIT BREAKER

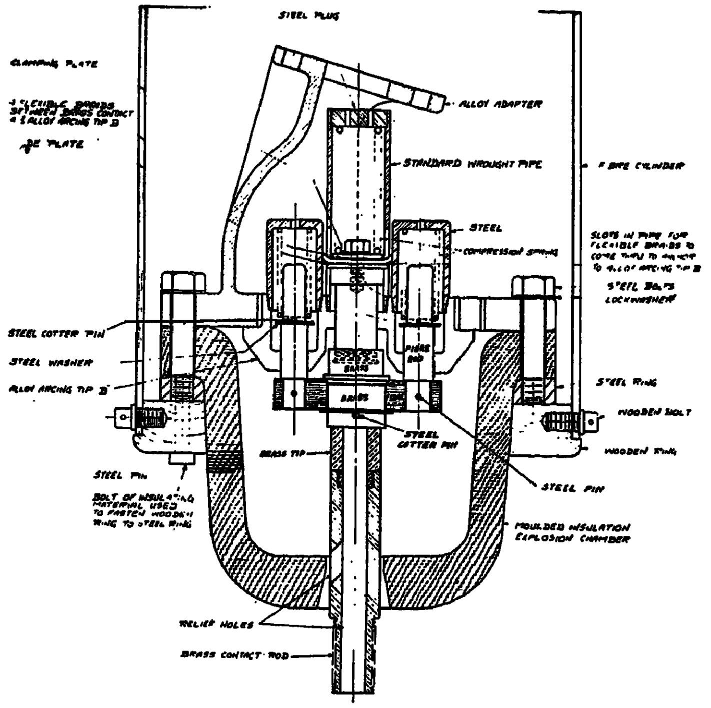
March 18 & 19, 1930

Kv.	Amperes	Arc duration Cycles	In. per break	Arc energy	Kv-a. x 1,000	Watts-secs. Kv-a.	Kv. per In. in arc
66	2,020–2,940	1.75–3.00	5.25– 7.50	23–35	171–194	0.118–0.187	4.4– 6.3
88	1,890–2,210	2.25–3.75	5.25–11.00	14–58	166–194	0.084–0.350	4.0– 8.4
110	1,540–1,740	2.25–3.75	5.25– 9.00	11–36	169–191	0.059–0.199	6.1–10.5
132	790–1,570	2.25–6.00	4.50–21.90	18–65	104–207	0.087–0.458	3.0–14.7

Contact burning negligible. No-load speed 7.8 ft. per sec.
Oil deterioration negligible.
No measurable pressure above oil.

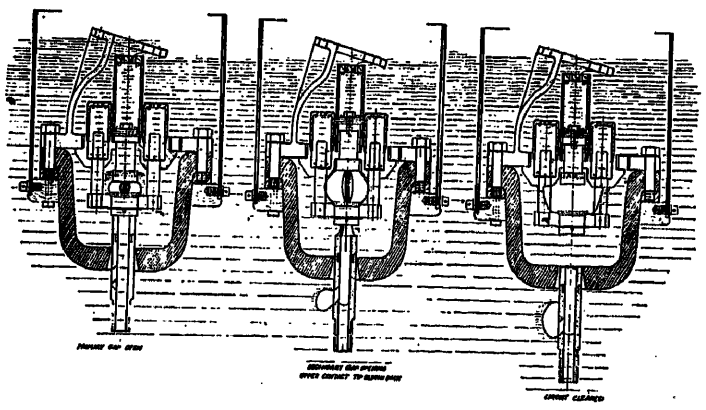
able improvement. Whereas with the standard explosion chamber, arc lengths vary from four to eight inches, those in Table I vary from 0.5 to 2.5 in.

At 110 kv., however, it was found more desirable to substitute molded explosion chambers for the steel chambers used at the lower voltages. Detailed arrangement of these chambers is given in Fig. 4. Oscillograms show that with this combination the arc duration is about three cycles, and both arc drop and arc energy are very low. Results of many tests are shown in Table II.



CLOSED POSITION

A



B C D

Fig. 6. Distribution of arcs and gas in four steps of operation of an oil-blast breaker

A 132-kv., 600-ampere breaker with the explosion-chamber arrangement just described was installed and tested under short-circuit conditions at the Philo plant of the American Gas and Electric Company. Its actual over-all interrupting time as compared with an ordinary butt-contact explosion-chamber breaker is revealed in Fig. 5. Field data gathered in these tests are presented and discussed in a paper prepared and presented by R. M. Spurck and H. E. Strang, at the winter convention in New York Jan. 26-30, 1931. The gain in the case of the oil-blast contacts is more impressive when it is remembered that in both cases the mechanical time required to separate the contacts is the same.

During the tests it was found that in many cases the circuit has been successfully opened with chamber pressures less than those previously calculated as theoretically necessary. This is explained by a more complete analysis of the oil flow during the arcing period.

Fig. 6 shows a series of drawings representing the locations of arcs, gas, and contacts during an operation of the breaker; Fig. 6A, the contacts in the closed position and in Fig. 6B the upper contacts have parted, establishing the pressure-generating arc. In Fig. 6C the lower contacts have parted and the current is still considerable, giving a fat arc. It is, however, beginning to be carried down the contact tube—which has been freed of oil—and gas is commencing to escape from the vent holes. As the arc dwindles with the cyclic decay in current, the oil moves radially inward along an area many times larger than the bore of the contact tube. At the current zero (Fig. 6D) the velocity of gas moving downward into the tube becomes many times the velocity of the inward-flowing oil. In effect the rate at which solid oil dielectric replaces ionized gas is the velocity with which the gas can go through the bore of the contact rod. The gas may pass through the contact tube at the velocity of sound, 2300 ft. per sec. in oil circuit breaker gas at ordinary temperatures, while at arc temperatures it probably exceeds 10,000 ft. per sec., which accounts for the extraordinary rate at which the space once occupied by the arc recovers its dielectric strength.

The principle of employing oil only instead of mixed oil and gas as the interrupting medium in oil circuit breakers is not limited to the larger types; smaller types applying this principle are under development and tests already made indicate that large decreases in arc length and increases in interrupting capacity will be obtained in all cases.

As relatively newcomers in the oil circuit breaker field, the authors would have been utterly unable to obtain the results which have been yielded by this investigation without the fine cooperation of the General Electric Company. Specifically Messrs. W. K. Rankin and W. E. Paul have contributed many of the ideas on which this paper is based, while G. F. Davis and his testing staff has made possible important checks upon theory, as well as the determination of the performance characteristics of the final designs.

News
Of Institute and Related Activities

—Photo by Altwater & Bros., Pgh.

Pittsburgh, host city to the Institute in March, offers many features of interest

Middle Eastern District
Offers Promising Program for Pittsburgh Meeting

IN high technical values as well as in the diversive attractions offered by a membership gathering, the March meeting of the Institute's Middle Eastern District No. 2 will offer material which none can well afford to miss. The William Penn Hotel, Pittsburgh, Pa., will be headquarters, and the many additional possibilities afforded by the Pittsburgh area will be made available to our guests by the plans which the local committees are formulating. The city itself, possessed of rare scenic beauty, has elevations offering an unusual panoramic view of the junction of the Allegheny and Monongahela rivers where they unite to form the Ohio River; its geographic location is such as to make it a major center of distribution; its endowment of natural resources in the surrounding hills, too, make for a great manufacturing center—the "Steel and Electric City." As far as the eye can scan, span after span bridge the rivers, with traffic—train, boat, vehicular and pedestrian—unceasingly present; while the auxiliary municipalities with which the river banks are lined make the constantly stirring action of the area doubly interesting to the mind of the energetic engineer.

The technical program will include papers on such all-important subjects as the interconnections between utilities and industry, a description of the new primary network now being installed in Pittsburgh, a symposium on the latest methods of grounding, relaying and fault-correcting for transmission systems (including another paper by Miss Edith Clarke), the miscellaneous applications of power to industry, and a live discussion of today's communication problems.

Briefly stated, the program is as follows:

Outline of Program

Wednesday, March 11, 1931

9:00 a. m.	Registration
10:00 a. m.	Address of Welcome—President William S. Lee
10:15 a. m.	Technical Session No. 1
2:00 p. m.	Technical Session No. 2
8:15 p. m.	Theater Party

Thursday, March 12, 1931

9:30 a. m.	Technical Session No. 3
12:30 p. m.	Luncheon for Student Branch Counselors and Chairmen
2:00 p. m.	Student Session
2:00 p. m.	Inspection Trips
6:45 p. m.	Banquet and Dance

Friday, March 13, 1931

9:30 a. m.	Technical Session No. 4
12:30 p. m.	Luncheon for Student Branch Counselors
2:00 p. m.	Technical Session No. 5

Entertainment

On Wednesday evening tickets for any of the Pittsburgh theaters may be obtained at the registration desk.

Thursday evening's social events will be the banquet and dance held in the main ballroom of the William Penn Hotel. An excellent program of music has been prepared by Pittsburgh's leading orchestra; favors for the ladies, and other special features will enhance the pleasure of the occasion. Reservations may be made in advance for tables seating ten persons; the tickets will be $4.00 each.

Ladies' Program

For the ladies' entertainment the Ladies Committee has arranged a sightseeing trip and tea on Wednesday afternoon, a luncheon and bridge on Thursday afternoon, and an indoor golf tournament and luncheon Friday morning.

Inspection Trips

The following inspection trips, which will afford an opportunity to see many recent developments of interest to the electrical engineering profession, have been planned for Thursday afternoon, March 12th:

1. The new KDKA broadcasting station at Saxonburg, Pa.
2. The East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company, including the new Central and High-Power Laboratory.
3. The Homestead Works of the Carnegie Steel Company.
4. The Springdale Power Station and Coal Mine of the West Penn Power Company.
5. The James H. Reed Power Station of the Duquesne Light Company.
6. The new 4000 volt primary network of the Duquesne Light Company.
7. The low-tension alternating-current network of the Duquesne Light Company.
8. The Bell Telephone Building, Pittsburgh.

A description of each of these trips with details of transportation, time, etc., will be announced in the program distributed prior to, and during the meeting.

In addition to the above, special inspection trips will also be arranged upon request; *i e.*, to the Lake Lynn Hydro Station of the West Penn Power Company, or to other points of interest in the Pittsburgh district.

Railroad Information

Train reservations may be made at the hotels; further train information will be available at the meeting's information desk. There will be no special railroad rates.

Registration

Each member should register in advance by mail, thus permitting the early preparation of badges and the saving of considerable time and confusion at the registration desk.

Full information regarding the entire program will be mailed in advance to each member in the district; also a registration card, which should be returned promptly.

Committees

The personnel of the General Meeting Committee consists of the following: E. C. Stone, Vice-President, Middle Eastern District, No. 2; J. A. Cadwallader, Secretary, Middle Eastern District, No. 2; C. T. Sinclair, Chairman, General Committee; F. W. Braund, H. E. Dyche, F. C. Hanker, D. H. Kelly, H. C. Paiste and W. R. Work. Those who are making the local arrangements for the meeting are as follows: C. T. Sinclair, Chairman, General Committee; and the following who are chairmen of sub-committees: A. G. Butler, Inspection Trips; J. A. Cadwallader, Finance; Miss Karen Fladoes, Ladies Entertainment; F. C. Hanker, Meetings and Papers; Moreland King, Student Activities; R. L. Kirk, Publicity; J. A. MacGregor, Hotel Registration and Train Transportation; and W. B. Spellmire, Entertainment.

Hotel Reservations

Reservations for hotel accommodations should be made by writing directly to any one of the following hotels; William Penn, Fort Pitt, Pittsburgher, or Roosevelt. All of these are within easy walking distance of headquarters.

By special arrangement delegates may enjoy the privileges of the Keystone Athletic Club by making reservations through J. A. MacGregor, Bell Telephone Company, 19th floor, 416 Seventh Avenue.

The Engineers' Society of Western Pennsylvania, located in the basement of the William Penn Hotel, also have kindly offered the facilities of their club rooms to visiting engineers at the District meeting. These facilities include a very large and comfortable club room well furnished with magazines, card tables, and miscellaneous equipment. Delegates are urged to make full use of the facilities, which will be found a very great added convenience and pleasure during their stay.

In the matter of special hotel rooms desired for committee meetings, reservations should be made through Mr. MacGregor at the address given above.

Further information regarding hotel accommodations and rates will be included in the announcement to be mailed later.

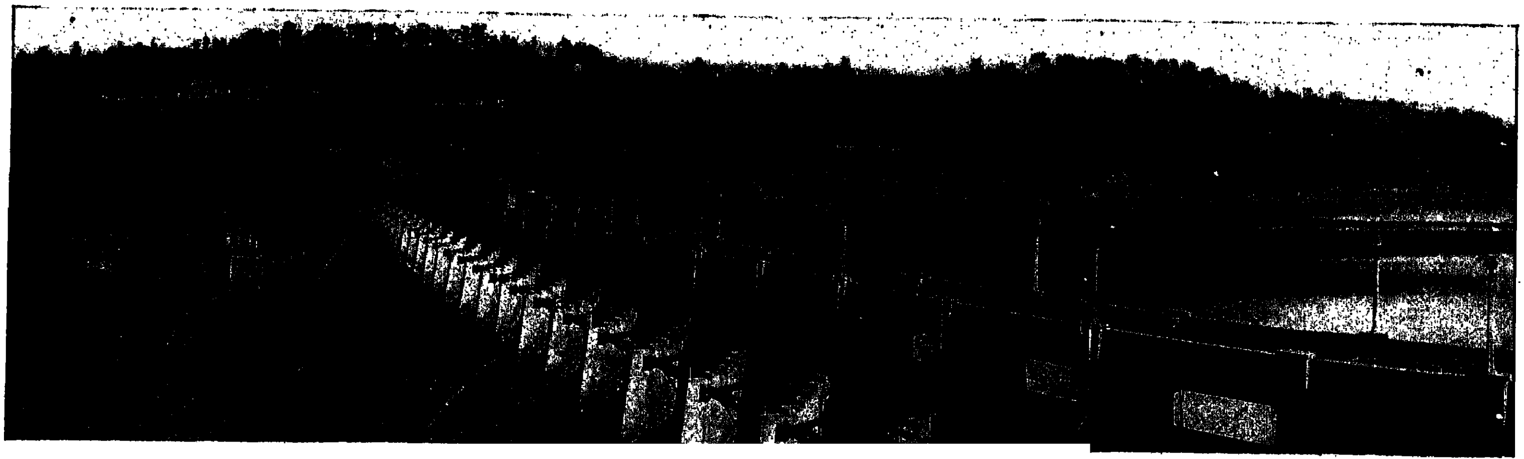
Technical Program

Wednesday, March 11—10:00 a.m.

Opening of Meeting

E. C. Stone, Vice-President, Middl Eastern District No. 2.

Address of Welcome, William S. Lee, President, American Institute of Electrical Engineers.



—Photo by L. F. Beaudry, Pgh.

Lake Lynn hydroelectric development of the West Penn Power Company

Session No. 1—On Cable Arcs and Arcs in Air

Sponsored by the Subcommittee on Distribution of the Power Transmission and Distribution Committee.

Burn-Off Characteristics of Low-Voltage Network Cables, G. Sutherland and D. S. MacCorkle, New York & Queens Electric Light & Power Company.

Arcs in Low-Voltage A-C. Network Cables, J. Slepian and A. P. Strom, Westinghouse Electric & Manufacturing Company.

The Re-ignition of Metallic A-C. Arcs in Air, S. S. Atwood, W. G. Dow, and W. Krousnick, University of Michigan.

Wedn sday, March 11—2:00 p. m.

Session No. 2—On Distribution Networks

Sponsored by the Subcommittee on Distribution of the Power Transmission and Distribution Committee.

Vertical Networks in Metropolitan Office Buildings, A. H. Kehoe, United Electric Light & Power Company, and Bassett Jones, Consulting Engineer.

The Primary Network, R. M. Stanley and C. T. Sinclair, Byllesby Engineering and Management Corporation.

Operating Experience with Philadelphia A-C. Network, H. S. Davis and W. R. Ross, Philadelphia Electric Company.

Prepared discussion—arrangements will be made for interested engineers to present prepared discussions on the problems involved in network distribution systems.

Thursday, March 12—9:30 a. m.

Session No. 3—On Grounding, Relaying and Transmission

Sponsored by the Protective Devices Committee.

Committee Report on Present Day Grounding Practises, C. A. Powel, Chairman.

Reactance of Transmission Lines with Ground Return, J. E. Clem, General Electric Company.

Fundamental Basis of Distance Relaying, W. A. Lewis, Westinghouse Electric & Manufacturing Company.

Power System Voltages and Currents Under Fault Conditions, R. D. Evans and S. H. Wright, Westinghouse Electric & Manufacturing Company.

Simultaneous Faults and Six-Phase Transmission, Edith Clarke, General Electric Company.

Thursday, March 12—2:00 p. m.

Student Session

Address, William S. Lee, President, American Institute of Electrical Engineers.

Summer Employment for Engineering Students, Wm. D. Bruce, University of Pennsylvania, and M. M. Boring, General Electric Company.

Qualifications Looked for in a Cadet Engineer, Lewis Fussell, Jr., Swarthmore, College, and Dr. E. B. Roberts, Westinghouse Electric and Manufacturing Company.

Has the Student Branch any Responsibilities to the Freshman and Sophomore? P. W. Seal, Lehigh University and G. A. Sanow, Case School of Applied Science.

A Review of Student Branch Activities in District No. 2, Professor J. T. Walther, University of Akron.

Friday, March 13—9:30 a. m.

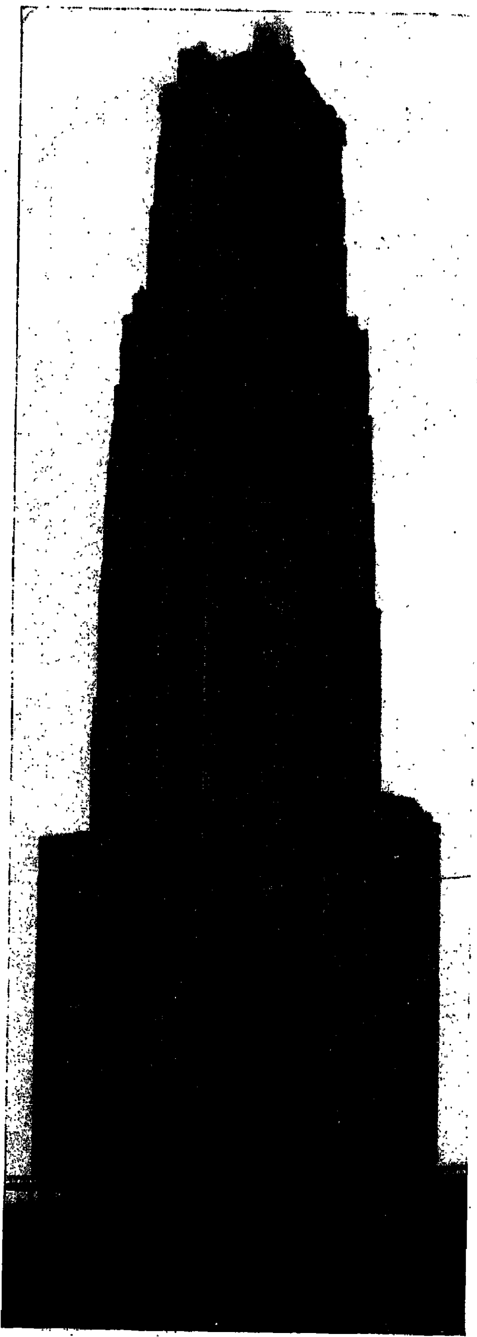
Session No. 4—Selected Subjects

Part I

Conversion and Distribution of General Purpose D-C. Power in Large Industrial Plants, R. D. Abbiss, Carnegie Steel Company, and D. C. West, Westinghouse Electric and Manufacturing Company.

Part II—Symposium on Interconnection between Utilities and Industries.

Interconnection Between the Duquesne Light Company and the Davison Coke & Iron Company, G. E. Dignan, Davison Coke & Iron Company, and R. L. Kirk, Duquesne Light Company.



A vertical campus; the University of Pittsburgh's Cathedral of Learning is nearing completion

Interconnection for Power Between Public Utilities and Large Industrial Users, F. O. Schnure, Bethlehem Steel Company.

Absorption of By-Product Power, A. Hoefle, Toledo Edison Company, and W. T. Woodmancy.

All the papers in this Session will be reprinted by the Association of Iron and Steel Electrical Engineers.

Friday, March 13—2:00 p. m.

Session No. 5—Selected Subjects

Part I—Industrial Power Applications

The Use of Electricity in Large Annealing Furnaces, J. C. Woodson, Westinghouse Electric & Manufacturing Company.

The Use of Electricity in a Modern Dairy Plant, H. C. Brunner, Westinghouse Electric & Manufacturing Company, and A. G. Droux, Rieck McJunkin Company.

Part II—Communications.

Description of KDKA Broadcasting Station, R. L. Davis, Westinghouse Electric & Manufacturing Company.

Power Supply for Telephone Systems, R. L. Young and R. L. Lunsford, American Telephone & Telegraph Company.

Power Supply for Telegraph Systems, E. W. Griffith.

Recent Developments in the Operation of Overseas Telephone Service, F. A. Cowan, American Telephone & Telegraph Company.

◆

Pacific Coast Convention Plans Announced

Taking advantage of the natural beauties and other attractive features of California's famous Lake Tahoe, the San Francisco Section, hosts to the 1931 Coast convention of the Institute have decided to hold that gathering at the mile-high lake resort. Facilities for technical inspection trips are generous and recreational possibilities are claimed to be second to none. Transportation both by rail and automobile is convenient, and excellent provisions are available for the convenience of family groups; hence there is the invitation to "make it your family vacation trip."

Tentative dates set are August 25-29 inclusive, a time chosen to synchronize with school terms.

Committee Appointments

Convention committee chairman as announced include A. W. Copley, general chairman; P. B. Garrett, general vice-chairman; E. F. Maryatt, general secretary; A. G. Jones, entertainment; E. A. Crellin, finance and hotel; A. V. Thompson, Golf; F. R. George, inspection trips; W. C. Heston, publicity; M. S. Barnes, registration; C. E. Fleager, (Eighth District vice-president) reception; D. I. Cone, technical program; Prof. S. G. Palmer, student activities; Paul Lebenbaum, transportation.

◆ ◆ ◆

Units and Definitions Adopted by International Electrotechnical Commission

INTERNATIONAL agreement on the definitions and names of additional magnetic units was reached by the International Electrotechnical Commission at its meeting in Oslo (Scandinavia) July 1930. This constitutes a further important advance in the standardization of electromagnetic units brought about through the efforts of this commission. The following is an unofficial summary of the actions taken:

The story begins with the preceding plenary I. E. C. meeting in 1927 at Bellagio, when a proposal was presented by the Italian National Committee, to adopt a unit of magnetic flux Φ, in the practical or volt-ampere-ohm system of units, with a certain definite name. For consideration and report the proposal was referred to a special subcommittee of advisory committee No. 1, on nomenclature to be known as the Subcommittee on Magnetic Units, and comprised of one representative from each of seven National Committees (France, Germany, Great Britain, Holland, Italy, U. S. A. and U. S. S. R.).

The members of this subcommittee exchanged much friendly correspondence upon the subject; but their views differed materially and no consensus of opinion could be reached. It was therefore decided to ventilate the question by papers and discussions in the various countries and I. E. C. national committees, with a view to paving the way for international agreement at the 1930 plenary Scandinavian meeting.

The I. E. C. Subcommittee on Magnetic Units agreed to attempt a revision of the C. G. S. units adopted at Paris in 1900, but in order to do so, it was first necessary to reach international agreement on the fundamental definitions of the C. G. S. magnetic units, and especially of magnetic permeability μ, on which question, differences of opinion have appeared in nearly all countries.

It is universally agreed that in a vacuum or in free space, with C. G. S. units, a uniform magnetising force $\mathcal{H}$ produces a uniform flux density $\mathcal{B}$ of the same numerical value; so that *space permeability* μ_0, or the ratio $\mathcal{B}/\mathcal{H}$, in free space, is unity. It has been much debated, however, whether, admitting that $\mathcal{H} = 20$ say, produces also $\mathcal{B} = 20$ in free space, the flux density $\mathcal{B}$ is identically the same physical quantity as $\mathcal{H}$; or whether the $\mathcal{H}$ sets up a quantity $\mathcal{B}$, which, although numerically the same, is physically different. If $\mathcal{H}$ and $\mathcal{B}$ are physically identical, it is not only superfluous but misleading to call them by different names and give them different units. The same unit *gauss* if applied to one would necessarily apply to the other. If, on the contrary, flux density $\mathcal{B}$ differs essentially from magnetising force $\mathcal{H}$; then it becomes necessary to have different units for these quantities, even if agreement cannot be reached as to the absolute dimensions of $\mathcal{B}$ and $\mathcal{H}$ in terms of length, mass, and time.

Decision at Stockholm on the Question of Permeability

At the first meeting of the Subcommittee on Magnetic Units, it was unanimously agreed to accept the hypothesis that for electrotechnical purposes, $\mathcal{B}$ and $\mathcal{H}$ in free space have different physical dimensions; so that their ratio μ_0 the space permeability, is a dimensional quantity and not the mere numeric unity (in the C. G. S. system).

It was also unanimously agreed that the ratio μ/μ_0 of the absolute permeability of a magnetic substance such as steel to the space permeability should be called its *relative permeability*, and should be taken as a pure numeric. Consequently when speaking of steel at a certain magnetising force as having an *absolute permeability* μ, of, say, 1,000, this is a dimensional quantity of the same dimensions as *space permeability* μ_0; but if we speak of its *relative permeability* μ/μ_0 as being 1,000, we refer to a mere numeric.

Formation of I. E. C. Subcommittee on Units and Magnitudes

The Subcommittee on Magnetic Units was enlarged in scope and membership by the I. E. C. committee No. 1 on nomenclature, with the new title, "Subcommittee on Electric and Magnetic Units and Magnitudes," and representatives of four additional national committees were appointed to it. The new subcommittee (E&M U&M) has one representative from each of the following national I. E. C. committees: France, Germany, Great Britain, Holland, Italy, Norway, Poland, Roumania, Spain, U. S. S. R. and U. S. A.

Names Adopted for C. G. S. Magnetic Units

The permeability question having been settled unanimously, the new subcommittee adopted either unanimously or by a large majority the following names for C. G. S. magnetic units:

For magnetomotive force (force magnetomotrice) . . . $\mathcal{F}$ the name *gilbert*
For magnetising force (champ magnetique) . . . . $\mathcal{H}$ the name *oersted*
For magnetic flux (flux magnetique) . . . . Φ the name *maxwell*
For magnetic flux density (induction) . . . . $\mathcal{B}$ the name *gauss*

It was urged on behalf of the Danish National Committee, that although the name oersted had been used in America for the C. G. S. unit of reluctance, yet this had never been adopted internationally; moreover, that Oersted had not interested himself in reluctance; but had actually discovered the magnetic field produced by an electric current. Consequently, it would be more rational to adopt the name *oersted* internationally for the unit of $\mathcal{H}$ than for the unit of R.

The following units in the C. G. S. magnetic system are thus left for the present without names;—reluctance, reluctivity, permeance, and permeability; however, these are units the names of which can be most readily spared by electrotechnicians.

For Use in the Practical System

In conformity with the Italian committee's proposal of 1927, the subcommittee unanimously adopted a practical unit of magnetic flux Φ with the value of 10^8 C. G. S. units, and with the name *pramaxwell*. (The prefix *pra* may be regarded as a contraction of the adjective "practical"—in French, "pratique"). It was also agreed to adopt the prefix *pra* as applicable for deriving practical units from corresponding C. G. S. units.

It was pointed out during the review of the subcommittee's resolutions by the main committee on nomenclature, that the *pramaxwell* as above defined was a definite unit magnitude and unit name concerning which there could be no misunderstanding or confusion; but that otherwise might be the case were attempts made to produce other practical magnetic units from the remaining members of the C. G. S. series. For instance misunderstanding and confusion might arise by using *pragilbert, praoersted, or pragauss.* This is because there are at least three different systems of "practical" units recognized today; namely, (a) the quadrant-eleventh-gram-second system of Maxwell; (b) the meter-kilogram-second system of Giorgi, and (c) the centimeter-gramseven-second system of Dellinger, Bennet, Karapetoff and Mie. Moreover, each of these three systems is sometimes claimed to be "rationalised" in modern technics, by the transfer of the factor 4π from magnetomotive force to reluctance. There might thus be at least two possible values for the "*pragilbert*" and six possible values for the "*pragauss*." Under these conditions so far as concerns the prefix *pra* it seems desirable, at least for the present, to limit the names for practical magnetic units to the *pramaxwell.* Of course the *ampere-turn* is a practical unit of magnetomotive force that has long been available and is free from ambiguity.

UNIT OF FREQUENCY

It was proposed by the German national committee to adopt the *hertz* as the international name of the unit of frequency, with the value of one cycle per second; but it was found impossible to reach agreement on this proposition, which was therefore referred back to the subcommittee for further consideration.

REACTIVE UNITS RELATING TO A-C. CIRCUITS AND SYSTEMS

The name *var* was adopted on a proposal of the Roumanian national committee, for the practical unit of reactive power in an a-c. circuit or system. This name *var* may be regarded as a contraction of the term "volt-ampere-reactif" or "reactive volt-ampere." The ordinary right-angle triangle, representing a-c. power, may thus be regarded as having *watts* for its base, *vars* for its perpendicular, and *volt-amperes* for its hypotenuse.

From the *var* the *kilovar* of 1,000 *vars* is derived in the regular way, expressible in the contracted form of *kvar.* Similarly, the product of the *var* and the hour gives rise to the *varhour,* expressible in the contraction *varh,* and likewise the *kilovar-hour* in the form *kvarh.*

It was proposed to adopt the term "hormanance" derived from a Greek verb meaning "excitation" as designating reactive power; but the motion was lost, and the matter was left for further study. It was then agreed to adopt provisionally the term "reactive power" itself. Thus, the a-c. power triangle would have *active power* as its base, *reactive power* as its perpendicular, and apparent power as its hypotenuse.

DEFINITION OF POWER FACTOR IN A SINUSOIDAL A-C. SYSTEM

In accordance with a proposal of the Roumanian national committee it was agreed to define the power factor of a sinusoidal a-c. system in the steady stat by the numerical value of the expression: $P/\sqrt{P^2 + P_r^2}$, either as a perunitage or a percentage; where P is the total active power of the system in *watts,* and P_r is the total reactive power of the system in *vars.*

DEFINITION OF POWER FACTOR IN A SINGLE-PHASE NON-SINUSOIDAL CIRCUIT

For the case of the general non-sinusoidal a-c. circuit it was agreed to adopt provisionally as the definition of the power factor, the numerical value of the expression: $P/(V\,I)$ where P is the active power in watts, and $V\,I$ is the apparent power, expressed as the product of the volts V and the amperes I.

Certain other subjects connected with reactive components in a general non-sinusoidal a-c. system were assigned for future discussion in the subcommittee, and also certain ambiguities in the use of existing electric and magnetic units. The hope was expressed that the appearance of premature and ill-considered new units in electrotechnical literature may be prevented by the work of the I. E. C. subcommittee on E&M U&M, to which the national committees may refer such questions advantageously for international consideration.

The resolutions of the Subcommittee on Electric and Magnetic Units and Magnitudes were reviewed and unanimously adopted by the main advisory committee No. 1 on nomenclature; thence reported to the plenary meeting of the I. E. C. in Oslo, July 9, 1930, where they were unanimously adopted.

NOTE: In connection with the adoption of the name *oersted* for the C. G. S. magnetic unit of magnetising force $\mathcal{H}$, as above outlined, it may be of interest to note that on June 27th, the opening day in Copenhagen, an official visit was made to the Oersted Statue in a park of that city. In the statue, Oersted is represented as observing the deflecting action of a voltaic-battery current upon a magnetic needle. With appropriate ceremonies, President Feldmann deposited at the base of the statue a suitably inscribed floral wreath.

(Signed) A. E. KENNELLY, Chairman,
Subcommittee on
Magnetic Units of the
UNITED STATES NATIONAL
COMMITTEE, I. E. C.

◆ ◆ ◆

1929 Census of Manufactures for Electrical Apparatus Shows 39% Increase

Announcement is made by the Bureau of the Census, Washington, D. C., December 31, 1930 that, according to preliminary tabulation of data collected in the Census of Manufactures taken in 1930, the total value of electrical machinery, apparatus, and supplies manufactured during 1929 in the United States amounted to $2,323,597,927, an increase of 39.3 per cent as compared with $1,668,104,965 for 1927, the last preceding census year.

The total for 1929 consisted of: Insulated wire and cable, $296,858,831; motors, exclusive of fan motors, $185,233,201; batteries, battery parts, and supplies, $145,207,574; industrial, commercial and domestic apparatus and appliances, $100,698,743; incandescent lamps, $85,319,515; switchboards, circuit breakers, and switches $79,424,219; transformers, induction voltage regulators, and current-limiting reactors, $78,114,532; generating apparatus and parts, $68,131,815; ignition apparatus for internal-combustion engines, $54,426,944; conduits and fittings, $46,915,073; wiring devices, $43,120,093; control apparatus, $42,541,032; measuring instruments, relays, and instrument transformers, $38,328,070; electrotherapeutic and electromedical apparatus, $19,957,011; fuses and fuse blocks, $13,420,285; electric fans, $11,560,642; miscellaneous electrical equipment, $936,059,847.

Of the total, $2,217,634,994 was contributed by those engaged primarily in the manufacture of electrical machinery, apparatus, and supplies, and the remaining $105,962,933 represented the value of such commodities made as secondary products by establishments engaged primarily in other lines of manufacture.

This industry embraces establishments engaged primarily in the manufacture of machinery, apparatus, and supplies for employment directly in the generation, storage, transmission, or utilization of electric energy. It does not cover establishments whose principal products are electric-lighting fixtures, electric signs, or motor-driven tools, mechanical refrigerators, washing machines, or other machines and appliances constructed with built-in motors, ignition apparatus, or other electrical equipment, unless the electrical equipment is made by the manufacturers of the machines or appliances and its value constitutes at least one-half of the total value of the machines or appliances.

Table I, below, gives summary statistics for the industry, for 1929 and 1927; Table II shows the values of the several broad classes or groups of products manufactured in 1929 and 1927. The figures for 1929 are preliminary and subject to revision.

TABLE I—SUMMARY FOR THE INDUSTRY: 1929 AND 1927

	1929	1927	Per cent of increase or decrease (−)
Number of establishments	1,798	1,177	1.2
Wage earners (average for the year)[1]	329,361	241,566	36.3
Wages[2]	$455,294,638	$336,238,750	35.4
Cost of materials, containers for products, fuel, and purchased electric current[2]	$921,190,963	$645,761,699	42.7
Products, total value[2]	$2,286,273,042	$1,637,307,035	39.6
Electrical machinery, apparatus, and supplies	$2,217,634,994	$1,551,816,138	42.9
Other products, and receipts for repairing	$68,638,048	$85,490,897	−19.7
Value added by manufacture[3]	$1,365,082,079	$991,545,336	37.7

[1] Not including salaried employees. The average number of wage earners is based on the numbers reported for the several months of the year. Because of the fact that manufacturers report the numbers employed on or about the 15th day of each month, as shown by the pay rolls, usually taking no account of the possibility that some or all of the wage earners may have been on part time or for some other reason may not actually have worked the entire month, this average somewhat exceeds the number that would have been required for the work performed if all had been continuously employed throughout the year. Thus in some cases the number reported for a given month exceeds the average for that month.

[2] Manufacturers' profits cannot be calculated from the census figures because no data are collected for certain expense items, such as interest on investment, rent, depreciation, taxes, insurance, and advertising.

[3] Value of products less cost of materials, containers for products, fuel, and purchased electric current.

TABLE II—ELECTRICAL APPARATUS, AND SUPPLIES PRODUCTION, BY CLASS AND VALUE: 1929 AND 1927

Class	1929	1927
Electrical machinery, apparatus, and supplies, all industries:		
Aggregate value	$2,328,597,927	$1,668,104,965
Made in the "Electrical machinery, apparatus and supplies" industry	$2,217,634,994	$1,551,816,138
Made as secondary products in other industries	105,962,933	116,288,827
Batteries, battery parts, and supplies	$145,207,574	*$146,693,521
Conduits and fittings	46,915,078	42,132,936
Control apparatus	42,451,032	*30,783,452
Fans, electric (including motors)	11,560,642	10,755,001
Electrotherapeutic and electromedical (including dental) apparatus	19,957,011	16,149,405
Fuses	10,784,689	8,811,050
Fuse blocks	2,635,596	2,080,192
Generating apparatus and parts	68,131,815	*104,246,026
Ignition apparatus for internal-combustion engines	54,426,944	35,123,296
Industrial, commercial, and domestic apparatus and appliances:		
Industrial and commercial	23,808,290	12,761,010
Domestic (household)	76,890,453	77,519,218
Instruments—measuring, relays, and instrument transformers	38,328,070	34,133,212
Lamps, incandescent-filament (not including sockets and other fittings)	85,319,515	87,933,244
Motors, except fan motors (not including starters or controllers)	185,233,201	*111,819,855
Switchboards, circuit breakers, and switches	79,424,219	71,924,341
Transformers, induction voltage regulators, and current-limiting reactors (except radio and measuring-instrument transformers)	78,114,532	*66,266,216
Insulated wire and cable	296,858,831	210,047,947
Wiring devices	43,120,093	32,703,331
Miscellaneous	936,059,847	578,350,676

*Revised.

Winter Convention To Be Reported Upon

As this issue of ELECTRICAL ENGINEERING goes to press, the major technical meeting of the Institute, the winter convention, is assembling in the Engineering Societies Building at 33 West 39th Street, New York. Early registrations presage a heavy attendance and indicate a wide general interest in the fifty papers to be presented at ten technical sessions.

In the March issue ELECTRICAL ENGINEERING will present a news story covering the principal features of the gathering. If discussors of papers presented cooperate sufficiently promptly, there also will appear in that issue a resume of important discussions; otherwise they will appear in a subsequent issue.

◆

Another Welding Essay Prize Contest Announced

For the purpose of increasing "the knowledge of the adaptability of arc welding to industry more especially of the adaptability of welding in the redesign of present machinery cast-iron or riveted steel structures to welded steel structures" the Lincoln Electric Company of Lincoln, Ohio, has announced its second arc welding prize competition. A total of $17,500 in prizes is offered, divided as follows:

First-Prize Paper	$7,500
Second-Prize Paper	3,500
Third-Prize Paper	1,500
Fourth-Prize Paper	750
Fifth-Prize Paper	500
Sixth-Prize Paper	250
Seventh to Forty-First Prize Papers	100

According to the announcement any person or group of two or more persons in any country of the world may submit a paper in this competition. However, mandatory requirements listed by the Lincoln Company include: (1) Only one paper from any competitor or group; (2) debarment of all Lincoln Company employees; (3) actual participation by each contributor in the work that forms the subject matter of his paper; (4) that descriptions be practical and readily understandable; (5) the machine or structure described must actually have been designed; (6) subject and illustrative matter must be in the English language; and (7) manuscripts must be mailed prior to October 1, 1931, arriving in Cleveland on or before October 31, 1931.

It is stated also that the subject matter of a paper submitted in the prize contest must come under one of the two following headings:

"(A) A description of a useful machine, structure, or building previously made in some other way that has been redesigned in whole or in part, so that arc welding is applied to its manufacture.

(B) A description of a machine, structure, or building not previously made that has been designed in whole or in part to the use of arc welding and a description showing how a useful result is obtained which was impractical by means of other methods of manufacture. It is not necessary that the machine as redesigned should have been manufactured at the time of writing the paper."

Details and further information are available from the Lincoln Electric Company, P. O. Box 683, Cleveland, Ohio.

◆

American-Scandinavian Fellowships Due for Consideration

In April, 1931, the American-Scandinavian Foundation will award to students of American birth a number of traveling fellowships for study in Scandinavian countries during the academic year 1931-1932, each fellowship to carry with it a salary of $1,000.

Graduate students and younger instructors and professors in American colleges are especially urged to become candidates; and it is preferred that all applications first be considered by their suitable college or university authorities.

Chairman of the final jury of award is Professor William Hovgaard of M. I. T. and as the meeting of the jury takes place in April, it is of importance that all nominations be well in hand by March 1st.

Send for details to Neilson Abeel, Secretary to the Foundation, 25 West Forty-Fifth Street, New York, N. Y. He will gladly supply application blanks and full information as to course of further procedure.

◆

Lehigh University Announces Fellowships

Up to April 1st, C. R. Richards, president of Lehigh University will receive applications for fellowships in Lehigh's Institute of Research, as follows:

One: Henry Marison Byllesby Research Fellowship in any branch of science or technology dealing with technical problems of interest to the public utilities.

One: James Ward Packard Research Fellowship in electrical or mechanical engineering,

One: C. Kemble Baldwin Research Fellowship in any branch of science having a direct bearing on aeronautical engineering.

Two or more: Institute of Research Fellowships.

Stipends for these several fellowships will be $750 for the Byllesby, Baldwin, and Packard and $600 for the Institute of Research Fellowship, for each ten-month period, with freedom from tuition fees.

Applicants are requested to present full statement of training and experience; also a transcript of academic record, list of references, and a recent photograph.

◆

Yale Again Offers The Sterling Fellowships

Fellowships established by a gift of one million dollars from the trustees of the estate of the late John W. Sterling are offered again by Yale University, open to its own graduates and graduates of other approved universities and colleges in the United States and foreign countries, be they men or women professors or, instructors on leave of absence who wish to pursue studies and investigations under the direction of the faculty of the Graduate School at Yale or in affiliation with that body.

Stipends of the Fellowships range from $1,000 to $2,500 and more, dependent upon previous experience of the recipient and the character of the proposed investigation.

Applications must be submitted by March 1, 1931, addressed to Edgar S. Furniss, Dean of the Graduate School of Yale University, New Haven, Connecticut, upon blanks which may be obtained from him.

◆

Columbia University Offers E. E. Scholarships

Each year the governing bodies of Columbia University have placed at the disposal of the Institute a scholarship in Electrical Engineering in the School of Mines, Engineering, and Chemistry of Columbia University, for each class. The scholarship pays $350 toward the annual tuition fees which vary from $340 to $360, according to the details of the course selected. Reappointment of a student to the scholarship for the completion of his course is conditioned upon the maintenance of good standing in his work.

Applicants must meet the regular admission requirements, and all letters of application addressed to F. L. Hutchinson, the National Secretary, A. I. E. E., 33 West 39th St., New York, N. Y., should give age of candidate, place of birth, education, references, photograph, and reference to any other activities, such as athletics or working one's way through college. The last day for filing applications for the year 1931-32 will be June 1, 1931.

The course at the Columbia School of Mines, Engineering, and Chemistry is a three-year course on a graduate basis. Candidates must have had a general education, including considerable work in mathematics, physics, and chemistry. Three years of preparatory work with special attention to the three preparatory subjects mentioned in a good college or scientific school should be sufficient. A college graduate with a B. S. degree in engineering can generally qualify to advantage. The candidate is admitted on the basis of his previous collegiate record without undergoing special examination. Other qualifications being equal, members of Student Branches of the A. I. E. E. will be given preference.

The purpose of this advanced course is to produce a high type of engineer, trained in the humanities as well as in the fundamentals of his profession. It is hoped that Enrolled Students and others qualified will show a keen interest in this scholarship.

◆

Subway Noise Given Technical Attention

In the January issue of Electrical Engineering appeared a few of the facts on "Noise Measurement" as recently placed before the Middle Eastern District Meeting at Philadelphia, by John C. Steinberg, telephone quality engineer for the Bell Telephone Laboratories.

Offering encouragement to Mr. Steinberg's efforts there has now been appointed by the Board of Transportation of the City of New York, a group of acoustical engineers to make technical study of noises resulting from elevated and subway traffic, and to return a report upon applications possible to limit or eliminate these noises.

G. T. Stanton, acoustic consulting superintendent of Electrical Research Products, Inc., and an Associate of the Institute, has been given charge of these investigations and is carrying on tests to discover the exact causes of these noises and just where their volume is greatest. A test trip to the Battery reported in the daily press seemed to demonstrate that without a doubt the acceleration of motors is directly responsible for the greatest amount of noise emanating from any single source. Except in instances where one train was passing another, the highest level of noise was *inside* of the cars and not outside upon the tracks as most riders would suppose, the bulk of the noise appearing to be attributable to the grinding of gears, motors, and wheels beneath the car floor. With no ready escape in this region, the noises reverberate within the car causing a greatly increased volume of sound.

St. Lawrence Commission Wants Immediate Action

The immediate creation of a public "Power Authority" for the International Section of the St. Lawrence River development has been recommended to Governor Roosevelt and the New York Legislature by the Saint Lawrence Power Development Commission of which Robert M. Haig is chairman.

An engineering report has been made covering the project, and to quote the commission, "it has been found entirely practicable to construct the necessary project . . . utilizing existing transmission and distribution systems . . . under contract with operating companies to assure them fair remuneration for their services and assure to the consumer the advantages of low-cost power . . . Terms of such contract to be worked out upon basis of actual cost for generating, transmitting and distributing power.

"It is estimated that by 1937 the total generation of power in New York State will exceed 20,000,000,000 kw-hr. as compared with 13,000,000,000 kw-hr. in 1929."

Departing from many plans previously offered by Canadian and American engineering groups, the Commission recommends a one-dam, two-step development at Messena Point, New York—farther down stream than priorly considered, which it contends will "reduce construction costs, construction time, produce more power with the flooding of a minimum acreage and make for the elimination of the more serious hazard of building power house and spillway on what is now dry land."

By the New York press, the whole situation appears to be looked upon as largely a political development.

◆

The Midwest Power Conference Meets at Chicago in February

In view of the existing economic conditions and the relation between business economics and the power industry, what promises to be the most significant conference on power machinery for years will be held in Chicago February 10-14, inclusive, when nationally recognized authorities on power will address the Fifth Midwest Power Engineering Conference, and the Fourth National Fuels Meeting of the American Society of Mechanical Engineers at the Stevens Hotel.

Simultaneously, the Midwest Engineering Exposition will present at the Coliseum a "cross-section" of the newest developments in power machinery and appliances: G. E. Pfisterer, who is managing director of the exposition, reports that a realization of the absolute necessity of revaluating the many factors in power economics to meet both present and future conditions has created an unusually keen interest in this forthcoming event, which will not only present important possibilities to the experienced engineers but will also offer to young engineers the opportunity in a common meeting place for an interchange of views, the forming of contracts, and assimilation of the latest developments in the field of engineering.

Upward of 200 leading manufacturers of power machinery and appliances have engaged display space and all arrows seem to point to a full occupancy of the 85,000 square feet available at the Coliseum. Unusual exhibits of heating, ventilating and refrigerating machinery, demonstrating the gains which have been made in these various branches and further development along new lines, seems assured. The refrigerating industry, especially, is in a state of flux and the newer methods and appliances which will be displayed at this exhibition should be of intense interest.

Another important field will be that of generation, utilization and distribution of power, covering as it does the entire range of the power industry. Engineers will be able to study their specific problems, as many of the demonstrations will be by actual operation.

◆

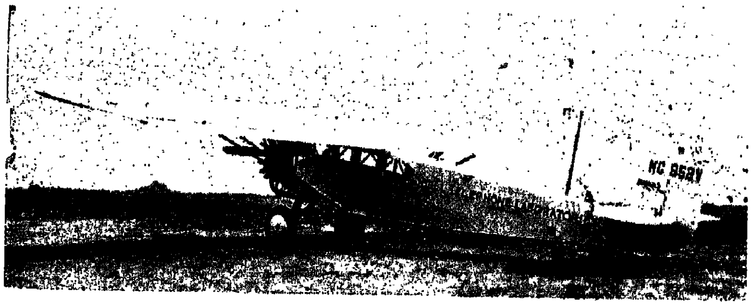
Shall Advertising Menace Radio Programs?

That the real usefulness and benefit of radio program possibility is being materially hampered if not actually jeopardized by a superabundance of the commercial advertising element was stressed by Doctor Lee de Forest, retiring president of the Institute of Radio Engineers in his farewell address on the evening of January 6th. Doctor de Forest is quoted as having asserted that the present "state of affairs is an unhealthy one and gives alarming symptoms for the future . . . that advertising from the local stations has become so uncontrolled that one wonders at the patience of a suffering public."

Just what may be done to reduce or eliminate this so-called "cancerous growth" remains for the future to discover; it would appear that much of the sales talk and cheap mediocrity of advertising program selections now being broadcast might well be dispensed with and result in very real benefit to public listeners.

◆ ◆ ◆

Aircraft Radio Development Continues



FAIRCHILD 71-A monoplane acquired recently by the Bell Telephone Laboratories, New York, for further practical experimentation in two-way radio communication between planes and between planes and ground stations. Long- and short-wave equipment is installed, powered by a small dynamotor in conjunction with a storage battery.

That police officers patrolling a city from the air may actually be in closer touch with headquarters than the patrolman on the street was demonstrated in a recent practical experiment. Officials in this plane, officials in the laboratories' Ford plane, and officials in the New York police commissioner's office were participants in two-way and three-way communication between the planes and between the planes and ground, while the two planes were aloft over two widely separated parts of the city.

Some of the possibilities immediately suggesting themselves include the pursuit of criminals operating in high-powered automobiles, the untangling of highway traffic jams, and cooperation with fire departments in large water-front or industrial fires.

New Recommendations for Electricity on Shipboard

A 1930 edition of "Recommended practise for Electrical Installations on Shipboard" has just become available. The pamphlet, which was originally known as "Marine Rules" has been developed under the auspices of the A. I. E. E. committee on application to marine work and in its new edition includes extensive revision of the 1927 issue, with considerable of new material on such points as motor-operated, water-tight doors, electric brakes, radio compasses, etc. It is known as Section 45 in the Institute's Standards series, and is on sale at a price of $1.50 per copy with a 50 per cent discount to Institute members.

◆

A $5,000 X-Ray Screw Driver

According to recent press reports from Stanford University (California) the versatile X-ray has been harnessed to the lowly task of driving screws.

It is said that P. A. Ross, the inventor, physics professor at Stanford, uses his machine as demonstrable support for the theory that X-rays behave like bullets rather than like waves, as is popularly believed. His equipment consists principally of an X-ray spectrometer. Indications are that the new device will not, however, at once displace the ordinary household tool, for it admittedly requires a lot of screw-driving to warrant a $5,000 implement. But it is stimulating, to allow free rein to the imagination in considering some of the many possibilities of little-known forces.

◆

East River Tube Projected for New York

It is reported that the War Department at Washington already has approved proposed construction of $50,000,000 twin vehicular tunnels under the East River, New York, the city being committed to the project by an appropriation of $350,000 for borings, engineering studies, and estimates. Actual report by the city's Board of Transportation has not yet been forthcoming, and John H. Delaney, chairman is quoted as having stated that "recommendations would probably be made within the next three months."

The tubes would connect Borden Avenue, Queens, with East 37th and 38th Streets, Manhattan, and would form the eastern third of a vehicular channel proposed for fast middle-Manhattan crosstown traffic, ultimately to cross Manhattan underground to the Hudson River and thence to Weehawken, N. J., via another bore. Preliminary investigations have been completed, and the issue awaited now seems to be an economic one to prove or disprove its feasibility.

◆

Nearly 14 Million Miles Phone Wire in New York City Area

New York City is served by 9,400,000 mi. of telephone wire, about 495,000 mi. of which was installed during 1930, according to a review for the year issued today by J. S. McCulloh, president of the New York Telephone Company. Manhattan alone has a total of 3,734,000 mi. of wire, of which 254,000 were added during the year.

More than 98 per cent. of all telephone wire mileage is now enclosed in storm-proof cable, the report shows. Twenty new central offices, including nine in New York City, installed in 1930 bring the total in service in the company's territory to 494. The wire mileage interconnecting the telephones served by the company was increased in 1930 by 948,000 to a present total of 13,750,000 mi.

◆

Vestal Copyright Bill Recommended

Edwin J. Prindle, chairman of the Pentent Committee, has recommended that the American Engineering Council endorse the Vestal Copyright Bill, H. R. 12549. This House bill provides (1) for automatic copyright, (2) that the author may divide such copyright into separate ways in which it is capable of utilization, (3) that all authors, be they American or foreign, will have automatic copyright in all countries which are members of the International Copyright Union, (4) that the term of copyright will be for the life of the author and fifty years after his death, and (5) that prints and labels for articles of manufacture are included in said copyright.

◆

Japanese Professor Arrives for Study of Electronics

Masaharu Hoshiai, assistant professor of electrical engineering at Tokyo Imperial University is now in New York, having been sent to America for a year's stay by the Denki-Gakkwai—the Institute of Electrical Engineers of Japan—under a grant from the Iwadare Fund for the encouragement of electrical science. Professor Hoshiai is the first person selected under this endowment.

Professor Hoshiai was graduated from the electrical engineering course of the Imperial University in 1922 and has since devoted his time to the study and teaching of electrical science at that University. The purpose of his visit is to extend his knowledge of applied electronics. Mail can be addressed to him in care of W. H. Capen, International Standard Electric Corporation, 67 Broad Street, New York City.

◆

Civil Engineers Elect Francis Lee Stuart

The opening session of its Wednesday morning meeting, January 21, saw the installation of Francis Lee Stuart, consulting engineer for the City of New York, as President of the American Society of Civil Engineers. As chief engineer of the Baltimore & Ohio Railroad from 1910 to 1915 and subsequently its consulting engineer, Mr. Stuart is of course well known in all railway and transportation circles. He has served also as chairman of the budget committee of the U. S. Railroad Administration in 1919 and in 1920 acted as consulting engineer to the Hydro-Electric Power Commission of Ontario (Canada).

In assuming his new office Mr. Stuart's message was directed toward the present critical situation facing business and industry and stressed the vital importance of the engineer's duty toward ultimate adjustment of financial, managerial, and economic complications through a better understanding of cause and effect.

Research and investigational activities of government bureaus in their importance to the engineering profession consumes the balance of Wednesday. In attendance at that meeting were George K. Burgess, director of the Bureau of Standards; J. D. Sears, administrative geologist of the United States Geological Survey; Major-General Lytle Brown, chief of U. S. Engineers, S. H. McCrory, and others of eminence.

The place of the civil engineer in the planning of cities, the prequalifications of highway contractors, and the use of natural gas for the generation of steam power, afforded no little food for debate. Thursday offered a full day for the discussion of these and several other interesting themes.

Friday closed the convention with excursions to New Jersey to inspect the recently constructed terminal of the Lackawanna Railroad, facilities of the

Newark airport and important highway and bridge construction now going forward under the direction of the New Jersey Highway Commission.

Social functions of the meeting included a dinner dance at the Roosevelt Hotel Wednesday evening, when Honorary Membership in the Society was conferred upon John R. Freeman, nationally known hydraulic engineer; and a smoker Thursday evening at which Doctor Roy Chapman Andrews told of his recent expedition to Central America. Approximately two thousand engineers from more remote sections of the country as well as those in proximity to the East attended and benefitted by the fellowship of the meeting.

Television Again Demonstrated

Previous application of this marvel of science has been so restricted to test and experiment that the "running public" have quite "counted themselves out" as a matter of course. Now things seem to be getting along and on January 7th, a "television tea" was given by Bell Telephone Laboratories and the American Telephone and Telegraph Company, jointly, when one group of woman guests gathered at one location were called separately to the telephone to greet "in person" the several members of a group at the other location. Many of these guests were members of the Woman's Engineering Club, and the tea proved highly instructive as well as diversive.

In this same field the use of television is being debated as an adjunct to police forces, to supplement police radio broadcasting already in action. Pictures of fugitives from justice would appear across the television screen in station houses or police patrol cars and the police would be given an actual visual knowledge of the person or persons to be apprehended. Chicago already is pioneering in this tryout as to the feasibility of police television and the authorities there after witnessing a demonstration through the *Chicago Daily News* experimental television station have recommended the adoption of visual radio in direction against and detection of crime. Mr. Wade, president of the Western Television Corporation of Chicago, by whom the demonstration was made, explained that the police department could have its own television transmitting station with television receivers in each outlying station house and that the police cruising cars now equipped with shortwave receivers could have also television receivers.

N. Y. Electrical Association Elects New Officers

Clarence L. Law, Associate A. I. E. E., general commercial manager of the New York Edison Company, and assistant to the vice-president of the Yonkers Electric Light and Power Company, was elected yesterday to the presidency of the Electrical Association of New York at its annual meeting at its headquarters, 100 East Forty-fifth Street.

Mr. Law succeeds Earl Whitehorne, assistant vice-president of the McGraw-Hill Publishing Company. Others elected at the association's meeting were Theodore H. Joseph, first vice-president; A. Lincoln Bush, second vice-president; H. H. Barnes, jr., third vice-president; Frank A. Pattison, fourth vice-president; L. L. Strauss, treasurer; Edward Ingraham, secretary, and J. A. Corcoran, assistant secretary.

◆

San Antonio Now has High-Pressure Plant

What is said to be the highest-pressure steam-electric generating unit now in commercial operation recently was placed in operation by the San Antonio Public Service Company in its Conception Road station. There the company has rebuilt what is generally known as Station B, by adding an 8,000-kv-a. unit to the 12,500-kw. unit of the original layout.

The rebuilt plant now consists of a 20,000-kw. compound unit designed for a maximum of 1,400 lb. pressure with a temperature of 825 deg. fahr. at the throttle. The combined units operate in parallel connection to the busbars and the old unit now constitutes the low-pressure stage of the whole, with an operating pressure of 175 lb., 550 deg.

Another interesting feature of the rebuilt is that the new high-pressure boiler is installed in the already existing boiler room, with the roof raised to accommodate the new equipment; the air heater and economizer are located outside of the building.

Another advantage, especially in this locality, lies in the fact that although the unit is designed primarily for oil firing, a natural gas fuel may be used if desired. With the installation of turning gears, the adjacent larger units will now be used for standby purposes or to handle peak loads. The company's engineers are most enthusiastic over these gears and are endorsing their further application on other standby units of the system.

American Engineering Council

A. E. C. will Participate in Washington Celebration

By special invitation from the George Washington Bicentennial Commission, and a set of resolutions approved and adopted at its last board meeting, the American Engineering Council will participate in plans for the national celebration of the 200th anniversary of the birth of George Washington, America's first engineer president.

By these resolutions, a copy of which was transmitted to S. Bloom, director of the commission, and incorporated in the official proceedings of the meeting, the Council pledges its earnest cooperation with the commission in such ways as may open to further the completeness of plans for suitable observance of this memorial date.

◆

Engineers Aid Hoover's Employment Committee

As the outgrowth of a conference of representatives of architects, contractors, engineers, and the steel, cement, and lumber industries called by Col. Arthur Woods, chairman of President Hoover's emergency committee for employment, there has been formed a public and semi-public works section of that committee. The purpose of that section is to endeavor to ascertain why works projects already authorized and for which appropriations have been made are not going forward, discovering if possible ways and means of expediting them so that the work will be undertaken promptly.

General C. W. Kutz, Corps of Engineers, U. S. A., (retired) is serving as the American Engineering Council's representative in this work, and the American Society of Civil Engineers has requested its local sections to serve as the principal field agencies for collecting necessary information. Emergency bills passed by Congress have removed some inhibitions of existing law or regulations in so far as the federal work is concerned and there are other bills pending which, if passed, will remove other impediments.

The President's emergency committee also desires to collect through the American Engineering Council information regarding any efforts made by employers to stabilize employment during the present emergency and any permanent plans adopted. Sections of the Institute and the American Society of Mechanical Engineers were requested in December to undertake this task. Results of their surveys give much of the desired information regarding employment conditions in the various industrial centers and the efforts of local organizations to bring about improvements.

A pamphlet entitled "Outline of Industrial Policies and Practises in Time of Reduced Operation and Employment" has been prepared for the emergency committee, and copies may be secured by addressing the committee, Department of Commerce Building, Washington, D. C.

A. E. C. Officers Elected at Annual Meeting; Business Stabilization Plans are Discussed

C. E. GRUNSKY, re-elected president of the American Engineering Council, presided at its annual meeting held at the Mayflower Hotel in Washington, D. C., Jan. 16-17, 1931. Other officers elected for the coming year included O. H. Koch of Dallas, Texas, and D. Robert Yarnell of Philadelphia, as vice-presidents; H. E. Howe of Washington, treasurer (re-elected); and Lawrence W. Wallace of Washington, executive secretary (re-elected). The other two vice-presidents, who continue for another year, are, Lewis Buckley Stillwell of New York and Gardner S. Williams of Ann Arbor, Mich.

Actions of importance to the nation, of interest to the engineering profession as a whole, and of particular interest to many individuals among the 59,000 professional engineers which it represents, were taken by the Council. These are outlined in the following paragraphs.

BUSINESS STABILIZATION

Seven principal points of attack on the problem of accomplishing business stabilization were recommended in a report prepared by a committee headed by Ralph E. Flanders of Springfield, Vt., vice-president of the American Society of Mechanical Engineers. The report recommended in part:

> (1) Maintaining or increasing the consumption of goods and services; (2) balancing plant, machinery and processes against production demands; (3) balancing distribution agencies against consumer requirements; (4) balancing manpower against production and distribution demands; (5) controlling money and credit to satisfy the needs of government, business, and the individual; (6) encouraging research activity to increase human well-being through development and progress in industry and business; balancing public works against public need.

The Council authorized its administrative board, and through it the executive committee, to take such steps as may be desirable to bring about such measures as the report recommends.

Further appropriations by the federal government to relieve the present depression were disapproved, and the proposal of a federal bond of 1,000 million dollars to construct public works was specifically opposed by the assembly, the legislative organ of the Council. Acting upon the recommendations of a committee headed by L. B. Stillwell of New York, the assembly opposed plans advocated by various organizations and individuals looking to the issuance by the federal government of large amounts of bonds for emergency construction work, on the grounds that:

> The organization and facilities of the several departments of the government, which under the law must direct this work, would not be able to expend with reasonable efficiency and within a period of two years any large amount in addition to the appropriations already made. Sums already made available by the federal, state, and municipal governments by the railroads, public utilities, and other corporations, are so large in the aggregate as to make the effect of an additional billion dollars which might be appropriated relatively of secondary or minor importance.

RECOMMENDATIONS ON FEDERAL PROJECTS

Establishment of a federal department of public works was urged by Major Gardner S. Williams, in his report as chairman of the committee on government reorganization. Major Williams stated the belief that the measure would not meet with as much opposition this time as previously experienced; and that it was becoming generally recognized that if such a department had been in existence for the past ten years or more a great deal of the present confusion in connection with the emergency construction of public works would have been avoided.

Opposition to all Muscle Shoals bills that contemplate government ownership or operation, or that set aside the intent and purpose of the Federal Water Power Act was reaffirmed by the Council.

A special committee appointed to study the McNary-Parker bills, which provide for the establishment and development of American transport services overseas, to encourage construction of American airships and other aircraft in the United States by American capital for use in foreign commerce and for other purposes, recommended that the Council support these bills in principle and allow the committee time for further study. The Council approved the recommendation.

The Council voted to use its influence to secure the appropriations necessary to the restoration of the locks in the Norfolk-Florida Canal.

Acting upon a carefully prepared recommendation of the Washington Society of Engineers, the Assembly voted:

> (1) That the Council strongly endorse the principle of the federal government paying all the necessary expenses of transporting civilian engineer employees, their dependents, and household effects, incurred by a change of station under competent orders. And since the executive committee of the interdepartmental board on simplified office procedure, office of the chief coordinator, now has under consideration a proposed act to provide for change-of-station allowances—
>
> (2) that a proper representative of the Council confer with the committee for the purpose of acquainting the committee with the Council's very keen interest in the matter, and with its desire to correct any inequities prevailing and to work with the committee to the end that any legislation it finally proposes will conform to the expressed desires of the Council.
>
> (3) That the Washington Society of Engineers be asked to continue its special committee so that the Council may call upon it from time to time for information and advice as the work proceeds.

PRESIDENT GRUNSKY'S SUGGESTIONS

A special committee appointed to study the president's speech at the opening of this session of the Council, found three important suggestions in the president's address which should receive careful consideration. The first suggestion, concerning the minimum height of bridges over navigable waters, was referred to the Council's committee on bridges.

The committee recommended that L. W. Wallace, executive secretary of the Council, be requested to take up with the Society of Naval Architects the matter of the maximum size of merchant ships in relation to docks and canals, and if possible secure their advice and opinion.

The third suggestion, concerning the important question of the conservation of natural water resources, was referred to the Council's committee on water resources.

ACTION ON CONGRESSIONAL BILLS

The Assembly, at the recommendation of the Committee on Public Affairs, considered a number of bills now pending in Congress, and voted on the attitude of the Council in regard to them. The Assembly voted actively to oppose S.5209, S.4819, and S.4938,—three bills on the subject of road legislation. The Council will support H. R. 13576, another road bill, and bills S.4791 and S.5021 concerning federal building programs.

The subject of a new naval towing tank in Washington was considered by the Council, and the following resolution passed:

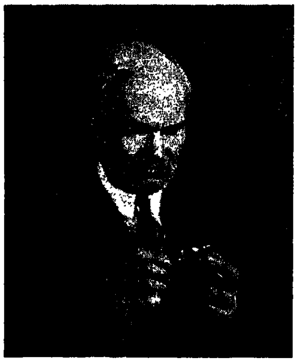
> *Whereas*, the present naval towing tank in Washington, D. C., is inadequate for modern experimentation and not equal in size and other facilities to those maintained by the most modern and progressive nations, and
>
> *Whereas*, the Navy Department is requesting an appropriation for the construction of a new naval towing tank along the Potomac in the vicinity of Cabin John Bridge, and
>
> *Whereas*, the American Engineering Council has supported similar projects for the benefit of scientific research in other departments, as for example, the National Hydraulic Laboratory at the Bureau of Standards, and
>
> *Whereas*, such an experimental model basin as proposed by the Navy would contribute incalculable values in keeping the United States in the forefront of naval construction and design,
>
> *Be it resolved*, that the public affairs committee recommends that the American Engineering Council endorse this project and appoint a special committee to confer with the naval authorities and members of Congress and offer to these agencies any practical assistance in securing the enactment of legislation looking to the creation of a new model basin towing tank.

The Assembly acted favorably upon the application of the Colorado Engineering Council, Denver, for membership in the American Engineering Council, and welcomed their representative, R. C. Gowdy, chief engineer of the Colorado and Southern Railway Company. Appointment of a representative on a joint committee to study prequalifications for contractors was authorized, but the Assembly declined to express its opinion at this time as to the advisability of such prequalifications.

Representatives of the American Institute of Electrical Engineers in attendance were A. W. Berresford, C. O. Bickelhaupt, F. J. Chesterman, M. M. Fowler, F. L. Hutchinson, W. S. Lee, William McClellan, L. F. Morehouse, I. E. Moultrop, Farley Osgood, W. S. Rodman, R. F. Schuchardt, Charles F. Scott, C. E. Skinner, Harold B. Smith and L. B. Stillwell.

Personal

LEE DE FOREST, retiring president of the Institute of Radio Engineers, and Fellow of the A. I. E. E., was born at Council Bluffs, Iowa. In 1896 he was graduated from Sheffield Scientific School of Yale University with the degree of B. S.; in 1899 he received his Ph. D., and in 1926 D. Sc., both from Yale. He has been identified with radio since the year 1901; in 1906 he patented the audion or three-element vacuum tube, and in the years that followed became an active worker in its various applications. Doctor de Forest has been the recipient of many honors, among them the Gold Medal of the St. Louis Exposition in 1904 for work on wireless telegraphy, the Gold Medal of the San Francisco Exposition in 1915 for his work in radiotelephony; the cross of the Legion of Honor from France; the Elliott Cresson Medal from the Franklin Institute; the Medal of Honor from the Institute of Radio Engineers, and the John Scott Medal from the City of Philadelphia.



LEE DE FOREST

Doctor de Forest assumed the presidency of the I. R. E. January 1930.

◆

RAY H. MANSON, a member of the Board of Direction of the Institute of Radio Engineers (1928), and a member of the A. I. E. E. since 1902, has been chosen president of the radio engineers, taking office at the recent January meeting.

He was born at Bath, Maine, was graduated from the University of Maine in 1898, and received his degree of E. E. from that institution in 1921. From 1899 to 1900 he was employed in the telephone manufacturing department and the electrical laboratory of the Western Electric Company in Chicago; the next four years were spent in the engineering and sales departments of the Kellogg Switchboard and Supply Company, Chicago. Then for a long period—until 1916—he was connected with the Dean Electric Company and its successor, the Garford Manufacturing Company of Elyria, Ohio, where for the last four years his service was as chief engineer. Since that date he has been busy with the Stromberg Carlson Telephone Company, Rochester, and is now its chief engineer and one of its vice-presidents.

During his affiliation with the manufacturing business, he has taken out over fifty patents on inventions in telephone, phonograph, and radio fields. He has been active also in radio standardization work in the radio division of the National Electric Light Association and is now chairman of its technical committee; for several years, he has been serving also as chairman of the electro-acoustic subcommittee of the I. R. E.

RAY H. MANSON

◆

ROBERT LEE WILSON, Fellow A. I. E. E and assistant to the president of the Westinghouse Electric and Manufacturing Company has resigned from that position. Mr. Wilson's resignation became effective December 31, 1930. While he will devote himself mainly to his private affairs, he will be retained by the Westinghouse Company on call in a consultative capacity, according to the statement made by F. A. Merrick, president of the company, in accepting the resignation.

In 37 years of service with Westinghouse Mr. Wilson rose from apprentice to draftsman, to inspector, road engineer, district engineer, superintendent of construction, superintendent of railway construction, assistant general superintendent, works manager, and then assistant to the president.

Born in Shelbyville, Ill., January 29, 1871, he was the son of Dr. William G. and Frances Anna (Lee) Wilson, who had moved to Illinois from Hartford county, Maryland. Mr. Wilson received his preliminary education in the public schools of Shelbyville, attended the University of Iowa for one year and Rose Polytechnic Institute, Terre Haute, Ind. for three years, graduating from the latter institution with the degree of bachelor of science in mechanical engineering in 1892. He took one year of post graduate work in electrical engineering at Johns Hopkins and started work for Westinghouse in 1894. He married Fanny Hampton Jeffers Kennard of Pittsburgh in 1900.

From 1903 to 1905, while he was district engineer with headquarters in New York, Mr. Wilson superintended the original electrification of the elevated and subway lines. While he was superintendent of railway construction from 1906 to 1909, he handled the biggest job ever undertaken by Westinghouse, the construction and installation of equipment for the electrification of the New York, New Haven and Hartford railway and the St. Clair tunnel of the Grand Trunk railroad. Much reconstruction work was necessary on these contracts; they were the first two important a-c. railroad electrification projects in the United States.

Mr. Wilson was one of the first industrial leaders to advocate elective representation in works councils and the amicable adjustment of disputes by joint conference committees representing management and employes. Recognition of his fairness and his service in employment and welfare work has come from all divisions of the Westinghouse organization. He was elected a member of the board of directors of the Westinghouse Veteran Employes' Association and has also been very active in other shop organizations.

◆

T. S. Perkins, formerly manager of supply engineering and consulting engineer for Westinghouse Electric & Manufacturing Company, has with the first of the year become its general manager of distribution engineering and will represent S. M. Kintner, assistant vice-president, in his work with several departments. Already Mr. Perkins has done much creditable work in his solution of complicated problems in the supply engineering department and standardization of production and design. R. W. Owens becomes general manager of industrial engineering and will represent Mr. Kintner in another group of the Westinghouse departments; most of his work has been in connection with motor engineering and he now falls into the field of the supervision of industrial motors, control, small motors and industrial heating engineering. At the Sharon works, W. M. McConahey has been appointed consulting engineer with headquarters in the transformer department, H. V. Putnam to succeed him as manager of the transformer engineering department. Other important changes effective January 1, 1931, are the appointment of M. S. Hancock as assistant manager of of the industrial motor engineering department and R. E. Marbury as assistant manager of the supply engineering department.

◆

W. S. Conlon has been named as successor to J. C. Williams, city engineer for Stamford, Connecticut. His varying work in the past as executive engineer, consulting engineer, designing and construction engineer, superintendent of construction and assistant engineer and assistant superintendent of construction of buildings, docks, sewage systems, water supply, etc., should make Mr. Conlon particularly well fitted for this new public works undertaking, especially as most of the past operations have been with engineering surveys and investigations in studies and reports for public utilities, railroads, etc., such as the New York subway and elevated service, the New England Power system in Vermont, New Hampshire, Rhode Island, Connecticut and Massachusetts, and other similarly representative organizations.

◆

H. O. Stephens, I. H. Sclater and A. B. Hendricks, Jr., have been appointed assistant engineers of the power transformer department of the General Electric Company, Pittsfield, Massachusetts, of which F. F. Brand is managing engineer. Mr. Stephens will be in charge of the design of oil-immersed transformers over 7,000-kv-a., air-blast transformers, reactors, and starting auto-transformers; Mr. Sclater will have charge of transformers from 501- to 7,000-kv-a., oil-immersed current and potential transformers, radio power, and other transformers; while the design of all developmental and high-voltage testing apparatus will come under the direct charge of Mr. Henricks.

◆

G. H. Cole on January 1 was transferred from the executive division of the American Rolling Mill Company, Middletown, Ohio, to become associate director of its research division. Extensive experience in the engineering and research work as well as his earlier service in the executive division of ARMCO will aid Mr. Cole greatly no doubt in his new field of service.

◆

Roy Page, who is vice-president and general manager of the Nebraska Power Company, Omaha, Nebraska, where he has always been active in civic affairs, was elected to the board of directors of the United States National Bank at its recent annual meeting. The United States National Bank is associated with the Northwestern Bancorporation.

◆

Louis Mackler, formerly electrical engineer with L. T. M. Ralston, Inc., New York City, has been appointed consulting engineer to the P. F. O'Keefe Advertising Agency, Inc. which has offices in Boston and New York. Mr. Mackler will remain in New York.

Obituary

Edward G. Connette, president of the United Gas & Electric Corp., and an expert in field utilities, died at Lockport, New York, December 30, 1930. Mr. Connette was a native of Austin, Indiana.

In his active career he started as telegraph operator in the mechanical and engineering departments of steam railroads where he shortly became assistant superintendent. In 1889 he took charge of street railway operations in Nashville, Tenn, and as superintendent equipped them with electric apparatus including the first double-reduction type of motors. After one year he was made general manager, at the same time serving as general manager and chief engineer of the Cumberland Electric Light & Power Company, Nashville, Tenn. His next service was as vice-president and general manager of the Syracuse Rapid Transit Railway Company, from which in 1905 he transferred to general managership of Worcester Consolidated Street Railway and subsidiary companies. This in 1909 led to his choice as transportation engineer for the public service commission's First District; there, besides being in full charge of the transit bureau, he supervised equipment of the inspection bureau (including power houses, transmission lines, cars, etc.) the accident bureau and appraisal bureau. Recently he had been associated with the J. G. White Management Company of New York City; he had served also as vice-president of the Wilkes-Barre Company, president of the United Gas and Electric Corporation, the Harrisburg Light Corporation Company, the Elmira Railway and Light Company and the Lockport Light and Gas Company, which latter he was visiting at the time of his death. For five years he was vice-president of the Syracuse Rapid Transit Railway Company, and for two years vice-president of the International Railway Company at Buffalo, New York, and afterward its president. He had served also as director and member of the executive committee of his company and vice-president, director and member of the executive committee of the International Traction Company. His club connections included the Municipal Engineers, the Buffalo Club, the Old Ellicott Club, the Wanakah Club, and the Country Club of Buffalo.

◆

Eugene A. Hart, a popular and active member of the Institute's Los Angeles Section, and manager of the transmission department of the General Electric Supply Corporation, Los Angeles, died at his home in that city December 11 after an extended illness of several months.

He was born at High Point, Missouri, April 1881 and after completing high school took special courses in electrical engineering. In 1896 he started an apprenticeship with the Los Angeles Electric Company which kept him busy until 1904; then he removed to Chicago to pursue his electrical bent in the meter department of the Commonwealth Electric Company. His general duties from 1904 to 1913 were in connection with small combination gas and electric plants of the Jefferson City (Mo.) Light Heat and Power Company; when he resigned he had advanced to the office of assistant manager. He then spent 3 years in electrical contracting, after which he became assistant manager of the Missouri Public Utilities Company at Poplar Bluff. This led to a managership of the company's operations in what was known as the Lead Belt Group, at Flat River, Mo., where he built the distribution systems and transmission lines for seven towns.

In 1917, he was transferred to become manager of its southeast Missouri group (13 towns) with headquarters at Cape Girardean, Mo., work involving a combination of water, gas, electric, and street railway properties, rebuilding all departments including 160 miles of power lines. The Los Angeles Gas and Electric Company induced him to enter its distribution department in 1924. From 1925 to 1927 he was sales engineer in charge of the transmission department of the Los Angeles district of the Pacific States electric Company, predecessor of the General Electric Supply Corporation.

◆

Samuel Winthrop Dean, Associate of the Institute, died January 8, 1931, in the Massachusetts General Hospital, Boston, after a long illness.

Mr. Dean was born August 29, 1897, at Cambridge, Mass. During the war he served as Ensign in the U. S. Naval Reserve Force. After graduation with A. B. degree from Harvard University in 1919, he was employed with the Radio Corporation of America until 1925, working on transmitting and receiving radiotelegraph problems. From 1925 until his illness he was with the development and research department of the American Telephone and Telegraph Company engaged in development of long-wave receiving systems for transatlantic radiotelephony. During this period Mr. Dean spent some time in England and Scotland. He was the author of several technical papers and was granted several patents.

◆

G. Stanley Covey, assistant service foreman of The Washington Water Power Company, Spokane, Washington, and an Associate of the Institute, died in December 1930. He was born in March 1878 at Jordan Falls, Shelburne County, Nova Scotia, and after attending both high school and private school took a special course in steam engineering. Later he spent three years in the operating department of the Pacific Electric Railway Company, Los Angeles, and one year as an engineer for the Southern California Edison Company at San Bernardino. He had been with the Washington Water Power ever since 1904, where his first services was principally on the operation of motors.

◆

Huibert Doyer, a Member for Life of the Institute and for many years a resident of Clos Myriel Chaillyvillage, Lausanne, Switzerland, recently died suddenly at his home. Mr. Doyer was born in Utrecht in 1862, and was a charter member of the Institute. He was graduated from the Holland Polytechnical School in Mechanical Engineering in 1885 and for sometime thereafter worked in the physical laboratory of that institution, in an ambition to promote so far as possible the electrical industry in Holland. He became internationally prominent, and now leaves behind him a host of friends, both in the profession and in civil life.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the Secretary at 33 West 39th St., New York, N. Y.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuming prompt delivery of Institute mail, the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work:

Bradford, A. O., Central Mex. Lt. & Pr. Co., San Luis Potosi, S. L. P., Mex.

Cromwell, P. C., Arthur Anderson & Co., 1814 Harris Trust Bldg., Chicago, Ill.

Davis, R. H., Westinghouse E. & M. Co., East Pittsburgh, Pa.

Dawson, Leonard L., 98 Looker Ave., Springfield, N. J.

Gale, R. E., 706 N. 19th St., Boise, Idaho

Herrera, R., Utah Pr. & Lt. Co., c/o Mr. Bennion, Salt Lake City, Utah

Kigar, D. F., 1403 Minnie St., Port Huron, Mich.

Lieb, Adolph W., N. Y. Edison Co., 393 7th Ave., New York, N. Y.

Mahnke, E. Chris, 1400 E. 53rd St., Chicago, Ill.

Prehn, Victor N., 940 Broad St., Newark, N. J.

Sherwood, W. E., Kew Gardens, 2700 Que St. N. W., Washington, D. C.

Sliney, David, 11 Orchard St., Cranford, N. J.

Vav Wyck, P. V. R., Summit, N. J.

Vreeland, F. P., 110 E. 176th St., New York, N. Y.

Williams, Clifton S., Research Lab., Westinghouse E. & M. Co., East Pittsburgh, Pa.

Local Meetings

New York Power Group to Meet Next in Newark

The Power Group of the Institute's New York Section will hold its next meeting in the Public Service Auditorium, 80 Park Place, Newark, New Jersey, the evening of Tuesday, February 17th, at 7:30 o'clock, with R. E. Powers of the Westinghouse Electric & Manufacturing Company as the speaker.

Mr. Powers takes for his subject "High-Speed Relaying and Switching," and will devote his time principally to showing how the margin of stability can be increased by increasing the speed of fault removal, as well as by speeding up the action of relays and circuit breakers. A general discussion in which all present should freely participate will follow Mr. Power's talk.

The nomination of Power Group officers for 1931-32 also will be considered at this meeting.

◆

Color in the Work World

On the evening of Tuesday, February 10th, the New York Section jointly with the A. S. M. E., the New York Electrical Society, and the Museum of Science and Industry, will hold a meeting on "Color in the Work World."

Chiefly, this will be a demonstration lecture by Doctor M. Luckiesh, director of the lighting research laboratory of the General Electric Company. Doctor Luckiesh, who has been making an exhaustive study of color and its effects upon the various processes of industry and occupational surroundings, is ably prepared to present his conclusions in a particularly interesting manner.

The meeting will be held in the auditorium of the Engineering Societies Building, 33 West 39th Street, New York, at 8:15 o'clock; because of the popular nature of the topic of the evening, admission will be by ticket only, but reservation forms will accompany the regular meeting notices sent out to the membership.

Future Section Meetings

Cleveland

February 19, 1931—Recent Progress in Communication Technology. Speaker from the Bell Telephone Laboratories, Inc., to be announced later.

March 19, 1931—Industrial Applications of Vacuum Tubes and Photo-Electric Cells, by E. L. Manning, General Electric Research Laboratories, Schenectady, N. Y.

Detroit-Ann Arbor

February 17, 1931—Detroit Toll Board, by E. C. Balch, Michigan Bell Telephone Co. Meeting at Michigan Bell Telephone Auditorium.

March 17, 1931—The Sound of a Shadow, by J. B. Taylor, General Electric Co.

Niagara Frontier

February 16, 1931—Air Circuit Breakers, by Mr. Gunion, I. T. E. Co.

March 20, 1931—Subject and speaker to be announced later.

Seattle

February 17, 1931—Operating Problems of Trunk Line Electrification, by J. Hawe, Electrical Engineer, Great Northern Railway.

March 17, 1931—Annual joint meeting of the Founders' Societies with program in charge of the American Society of Civil Engineers.

Sharon

February 3, 1931—Audible Light, by John B. Taylor, General Electric Co.

Spokane

March 27, 1931—Program by local members as follows: Service and Services, by G. S. Covey; Standard Meter Equipment, by J. G. Finley; Relay Application to Feeder Protection, by C. F. Norberg.

Past Section Meetings

Akron

Power Transformer Design and Tap Changing Under Load, by L. C. Nichols, Allis-Chalmers Mfg. Co. Film—"The Story of Bakelite Resinoid" presented. December 11. Attendance 70.

Baltimore

Recent Engineering Projects by the Bureau of Mechanical Service, by Warren Viessman, Mechanical-Electrical Engineer, City of Baltimore. Illustrated with views of the city's engineering developments in street lighting, airport illumination, power conduits owned by the city, city incineration, and power installations in various city buildings.

Water Works Pumpage—The Vernon Pumping Station, by Leon Small, Superintendent Engineering Division, City of Baltimore. Joint meeting with the A. S. M. E., A. S. C. E., and Baltimore Engineers Club. December 12. Attendance 58.

Boston

Recent International Understandings in Electrical Engineering and Radio, by Dr. A. E. Kennelly, Harvard University. December 9. Attendance 75.

Columbus

Chain Broadcasting and Teletype Operation, by J. T. Jenkins, American Tel. & Tel. Co. Accompanied by demonstrations of some apparatus used in teletype work. December 5. Attendance 65.

The Threshold of a New Era in Lighting, by T. P. Brown, Edison Lamp Works. Illustrated. January 9. Attendance 25.

Connecticut

High-Pressure Steam, by I. E. Moultrop, Edison Electric Illuminating Co. of Boston, and Vice-President District No. 1, A. I. E. E.;

Operating Results of the Mercury Turbine, by T. H. Soren, Hartford Electric Light Co. Meeting held at Hartford Electric Light Co., preceded by dinner at the City Club. December 15. Attendance 95.

Dallas

Meeting held under the auspices of the Student Branch at Southern Methodist University, at which the following papers were presented by Students:

Demonstration of Short-Wave Broadcasting, by D. J. Tucker;

Thermocouples, by R. L. Allen, Jr.;

Experiments with the Transformer, by Carlos Burnet. November 17. Attendance 75.

Annual Dance. December 15. Attendance 140.

Denver

The All-American Canal and the Problems of the Salton Basin, by M. M. McIntire, Imperial Irrigation District, Imperial, Calif. Illustrated with lantern slides. Dinner preceded the meeting. December 12. Attendance 32.

Detroit-Ann Arbor

Patents and Inventions, by George N. Willitts, General Motors Corporation, and Secretary Michigan Patent Law Association. Mr. Willitts pointed out the difficulties in the present patent procedure and outlined the reform in this system which the Michigan Patent Law Association has gone on record as favoring. Joint meeting with the Detroit Engineering Society. December 12. Attendance 125.

Fort Wayne

Transient Phenomena in Small Electromagnets, by H. H. Clayton, General Electric Co. Illustrated with slides.

Luminous Tubes and Transformers, by C. W. Kronmiller, General Electric Co. Considerable discussion followed. December 18. Attendance 70.

Houston

Banquet at which the members of the Section were guests of the International

Creosoting and Construction Co. Moving pictures were shown of modern methods used in the wood preserving industry. E. E. Boehne and Mr. Myers, both of the above company, explained various treatments and answered questions. December 16. Attendance 55.

Ithaca

Twentieth Century Developments in Our Knowledge of Matter and Energy, by Professor F. K. Richtmyer, Cornell University. December 12. Attendance 200.

Kansas City

Some Construction Details in an Industrial Power Plant, by C. O. Boynton, Standard Oil Co.;

Some Mechanical Engineering Problems in a Modern Oil Refinery, by W. L. Mathews, Standard Oil Co.;

Economic Design of Intercity Communication Facilities, by J. F. Burwick, Southwestern Bell Telephone Co.;

Intercity Communication Plant Construction, by J. H. Schweitzer, Southwestern Bell Telephone Co. Joint meeting with the University of Kansas Branches of A. I. E. E. and A. S. M. E. Buffet luncheon served at the close of the meeting. December 4. Attendance 180.

Lehigh Valley

Power Supply for Single-Phase Railroad Electrification, by R. T. Earle, Westinghouse Electric & Mfg. Co. C. L. Doud, Reading Railroad Co., outlined their activities in electrification in Philadelphia, and on some of their main trunk lines. Harvey Pierce, Stewart, James & Cook Co., who spent considerable time in Russia developing the coal fields, made a few remarks. Film—'Dynamic America," presented by E. M. Johnson, Westinghouse Electric & Mfg. Co. Meeting held at Pottsville. November 14. Attendance 73.

Recent Developments in the Art of Communication, by R. B. Parker, American Telephone & Telegraph Co. Illustrated with slides and an actual demonstration of the teletype. Film—"Transatlantic Radio Telephone Service." Joint meeting with the Student Branch at Lehigh University. December 5. Attendance 225.

Los Angeles

Sound Rays as Extremals, by Professor H. Bateman, California Institute of Technology. Discussion followed. December 15. Attendance 22.

Louisville

The Romance of Electric Cooking, by K. L. Aleshire, Westinghouse Electric & Mfg. Co. Electric ranges, electric refrigerators, and other appliances were demonstrated. Refreshments served. December 15. Attendance 40.

Madison

The Application of Automatic Control to Motor-Driven Machinery, by P. B. Harwood, Cutler-Hammer, Inc. Illustrated with slides. Refreshments served. November 19. Attendance 22.

Memphis

Lightning and Lightning Arresters, by H. T. Montgomery, General Electric Co. A motion picture was shown illustrating the construction of power transformers at the General Electric Works. December 9. Attendance 35.

Minnesota

Amusing Incidents of My Trip to Europe, by Milton Firestone, Attorney of St. Paul. Dinner preceded the meeting. December 17. Attendance 32.

Niagara Frontier

Armor-Clad Switchgear, by H. V. Nye, Allis-Chalmers Mfg. Co., illustrated. R. L. Melton, The Carborundum Company, gave a talk on the manufacture of abrasives, preceding the showing of the four reel film "The Jewels of Industry." An informal dinner in honor of the speakers was held at the Hotel Niagara. December 19. Attendance 85.

Oklahoma City

Protection of Power Transmission Equipment from Lightning, by Professor C. T. Almquist, University of Oklahoma.

Protection of Telephone Equipment from Lightning, by R. L. Jones, Southwestern Bell Telephone Co. General discussion of both talks followed. December 29. Attendance 59.

Philadelphia

Innovations in Remote Metering, by Alan S. Fitzgerald, Radio-Victor Corp. December 8. Attendance 150.

Problems in the Design of Large Turbo Alternators, by S. H. Mortensen, Allis-Chalmers Mfg. Co. Illustrated with slides which not only showed the steps in the manufacture of the various parts, but compared the European design with American practise. January 5. Attendance 105.

Pittsburgh

Proper Voltage and Lighting Service, by G. S. Merrill, General Electric Co.;

Artificial Sunlight, by M. Luckiesh, General Electric Co. Film—"Dynamic America" presented. Joint meeting with the Engineers' Society of Western Pennsylvania. December 9. Attendance 282.

Pittsfield

Telegraphy—A New Art with an Old Name, by J. H. Bell, Bell Telephone Laboratories, Inc. Illustrated with slides and curves. Dinner preceded the meeting. December 16. Attendance 175.

Rochester

Illumination, by Alvin L. Powell, General Electric Company. Illustrated with colored slides of modern uses of lighting. December 11. Attendance 186.

St. Louis

Some Recent Research Developments, by E. L. Manning, General Electric Co. C. B. Fall, Chairman, spoke of the legislation now under consideration for the licensing of engineers in Missouri, and appointed a committee to represent the interests of the Section. December 19. Attendance 95.

San Antonio

Film and descriptive talk on Fort Worth to Cisco Underground Toll Cable, by B. O. Timberlake, Southwestern Bell Telephone Co.;

Film and descriptive talk on Step by Step Machine Switching, by L. R. Norton, Southwestern Bell Telephone Co. Film—"Voices Across the Seas." December 15. Attendance 76.

Schenectady

Automotive Design, by John J Caton, Chrysler Motor Corporation. Discussion followed. November 21. Attendance 200.

Electricity—Past, Present, and Future, by C. M. Ripley, General Electric Co. Film—"Tipping the Chute—a Caron Obelisk." December 5. Attendance 250.

Seattle

A Resumé of Recent Developments in Predetermination of System Performance, by Dean H. V. Carpenter, State College of Washington. Discussion followed. December 23. Attendance 40.

Sharon

Split-Second Phenomena in Electrical Engineering, by Dr. Joseph Slepian, Westinghouse Electric & Mfg. Co., assisted by Dr. Phillips Thomas of the same company. Illustrated with slides and demonstrations, including a 250-kv. lightning generator, insulator strings, and auto valve arrester. Film showing equipment and operation of the Wildwood Mine of the Butler Consolidated Coal Company was supplemented by a description by Mr. Vance, Chief Engineer of that company. January 6. Attendance 140.

Springfield

The Marvels of Sound Transmission, by Sergius P. Grace, Assistant Vice-president, Bell Telephone Laboratories, Inc. Joint meeting with the Engineering Society of Western Massachusetts and the Springfield Chamber of Commerce. Dinner in honor of the speaker was given at the Colony Club. December 12-13. Attendance 9,000.

Toledo

Zig-Zag Transformers, by Alois Hoefle, Toledo Edison Co., illustrated with sketches and diagrams.

Economic Advantages of Electric Heat for Heat-Treating Processes, by Wirt S. Scott, Westinghouse Elec. & Mfg. Co., illustrated with lantern slides. December 19. Attendance 80.

Toronto

Changing Views of the Nature of Matter, by Dr. Saul Dushman, General Electric Co. Joint meeting with the Toronto Chemical Association. December 12. Attendance 300.

Hydrogen Cooling of Electrical Machinery, by C. J. Fechheimer, Westinghouse Electric & Mfg. Co., illustrated with slides. General discussion followed. January 9. Attendance 102.

Urban

Research Laboratory in a Large Manufacturing Company, by H. D. Sanborn, General Electric Co. Illustrated with lantern slides showing some of the wide variety of subjects undertaken in a research laboratory. December 19. Attendance 75.

Utah

Automatic Block Signals, by B. W. Molis, Denver & Rio Grande Western Railroad Co. Mr. Molis gave a description of the common forms of train control and signal arrangements, and had some apparatus for demonstration. Informal dinner preceded the meeting. December 8. Attendance 41.

Vancouver

Manufacture and Application of Vacuum Tubes, by G. W. Sweney, Neon Products of Western Canada Ltd. Lantern slides and films were shown illustrating the manufacture, installation, and application of neon tubes. November 17. Attendance 57.

Photoelectric Cells—Their Construction, Selection and Application, by Frank Sawford, Consulting Mechanical and Electrical Engineer. Charts were displayed and smoke-density metering equipment designed and patented by Mr. Sawford was set up for demonstration purposes. December 8. Attendance 53.

An Outline of Modern Automatic Telephone Practise, by R. S. Bowland, Independent Sales & Engineering Co. Illustrated with slides, and a demonstration, consisting of two telephones with their dials, switching equipment, and battery, was set up and operated. January 5. Attendance 52.

Washington

The Electrification of the Pennsylvania Railroad, by H. C. Griffith, Pennsylvania Railroad Co. Illustrated with slides showing various types of locomotives, overhead construction, and equipment used in construction work. Dinner in honor of the speaker preceded the meeting. December 9. Attendance 162.

Worcester

The Marvels of Sound Transmission, by Sergius P. Grace, Assistant Vice-president, Bell Telephone Laboratories, Inc. Meeting held under the auspices of the Worcester Engineering Society. December 17-18. Attendance 3500.

Insulated Wires and Cables for Power Circuits, by E. W. Davis, Simplex Wire & Cable Co. January 7. Attendance 35.

Past Branch Meetings

University of Akron

A History of Telephony, by Harold Schroeder, Branch Secretary. December 19. Attendance 18.

Alabama Polytechnic Institute

Steam Electric Power Plant, by L. O. Swint, Student;

Levee Construction Along the Mississippi River, by Charles Perry, Student;

Dirigible Construction, by E. C. Austin, Student. October 2. Attendance 36.

The Process of Manufacturing One Piece Wheel and Axle for Railroad Cars, by K. R. Clark, Student;

Testing Wattmeters, by J. M. Johnson, Student. October 9. Attendance 25.

Redevelopment of Hydroelectric Plants, by T. N. Pyke, Student;

Electricity's Part in Copper Mining, by G. A. Beavers, Student;

Experience Working with an Engineering Party, by H. L. Beck, Student. October 23. Attendance 16.

Smoker and entertainment. October 30. Attendance 76.

Molding Cast Iron Pipe by the Centrifugal Method, by S. E. Garrett, Student. November 6. Attendance 15.

R. A. Mann, representative of the Branch, outlined the activities of the District meeting held in Louisville. G. A. Beavers gave an account of the Eta Kappa Nu meeting held in Ames, Iowa. December 4. Attendance 17.

Election of officers as follows: R. A. Mann, Chairman; C. L. Perry, Vice-Chairman; L. B. Crouch, Secretary-Treasurer; K. R. Clark, Reporter. December 11. Attendance 12.

University of Alabama

Copper-Weld Wire, by W. B. McClure, Student;

Lightning Investigation on 110 Kv. Line, by Harold B. Hendrix, Branch Secretary. Walter H. Croft, Chairman, gave a report of his trip to the District meeting held in Louisville. December 8. Attendance 16.

University of Arizona

A Trip Through the East, by A. W. Fraps, Student. October 24. Attendance 10.

Industrial Use of Vacuum Tubes, by C. J. Sabin, Student. October 31. Attendance 8.

Television, by H. P. McGovern, Student. C. J. Sabin appointed Chairman of Electrical Show. November 7. Attendance 8.

A Brief Review of the Development of Power Plants, by Max Pooler, Tucson Gas, Electric Light and Power Company. Banquet meeting. November 19. Attendance 25.

Talkies, by J. C. Hall, Student. November 21. Attendance 9.

Business meeting. December 5. Attendance 10.

Circuit Breakers, by W. T. Brinton, Student;

Vacuum Tube Circuit Breaker, by Professor J. C. Clark, Counselor. December 12. Attendance 10.

Thermodynamic Regulator, by R. Manzo, Student. December 19. Attendance 10.

University of Arkansas

Film—"The Single Ridge." November 19. Attendance 22.

Grid-Glow Tube and Photoelectric Cell, by Wylie Head, Branch Secretary. Demonstrated. December 3. Attendance 23.

Armour Institute of Technology

Smoker. December 10. Attendance 87.

Industrial Electric Heating, by L. J. Ericsson, General Electric Co. Illustrated with motion pictures. December 15. Attendance 40.

Polytechnic Institute of Brooklyn

Substation Maintenance Practise, by Rodney Brabson, Student;

Electrolysis of Subway Cables in Telephone Work, by Leon K. Danner, Student;

High-Frequency Currents and Short Radio Waves as Valuable Adjuncts to the Medical Sciences, by Ivan Block, Student. There were two prizes; first won by Ivan Block, and second by Leon K. Danner. December 12. Attendance 33.

Carnegie Institute of Technology

Commercial Problems that an Electrical Engineer is Required to Face in the Steel Industry, by William Skinkle, United States Steel Corporation, and Director of the Engineers' Society of Western Pennsylvania. Illustrated with slides. November 13. Attendance 30.

Electrical Engineering in an Electric Public Utility, by R. L. Kirk, Duquesne Light Co. December 9. Attendance 85.

Catholic University of America

The Fundamentals of Radio, by Professor T. J. MacKavanagh, Counselor. December 16. Attendance 30.

University of Cincinnati

Public Utilities and the Public, by E. D. Gilman, Director, Public Utilities of the City of Cincinnati. December 10. Attendance 26.

Colorado Agricultural College

The Public Relations with Public Utilities, by Mr. Jamison, Public Service Co. of Colorado. December 8. Attendance 16.

University of Denver

Aviation Lighting, by F. L. Woodward, Student. November 8. Attendance 18.

Film—"Beyond the Microscope." December 12. Attendance 40.

University of Detroit

The Principles of X-Rays, by C. J. Haller, General Electric X-Ray Corporation. November 24. Attendance 40.

University of Florida

A history of the A. I. E. E. and its activities was given by Professor W. S. Rodman, University of Virginia, and Vice-President District No. 4, A. I. E. E. Professor Rodman also gave an address, Some Aspects of the Scientific Work of Thomas Jefferson, through the University of Florida radio station, WRUF. December 17. Attendance 63.

Arc Welding, by F. J. Nelson, Student. Discussion of Branch affairs. January 12. Attendance 20.

University of Iowa

Films—"The Wizardry of Wireless," and "Liquid Air." December 17. Attendance 40.

The Part of Electricity in Open-Cut Copper Mining, by Mr. Hammond, Student;

The Oscillograph, by Mr. Jenkins, Student. January 7. Attendance 41.

University of Kansas

The Design and Testing of Motion Picture Screens for Sound Picture Work, by Lester Perry, Student;

The Applications of Photoelectric Cells, by Louis Farber, Student. A three-reel film on transmission cable insulation was shown. December 18. Attendance 55.

Lehigh University

Recent Developments in the Art of Communication, by R. D. Porter, American Tel. & Tel. Co. Joint meeting with the Lehigh Valley Section. December 5. Attendance 250.

University of Maine

Election of officers as follows: Monroe E. Moon, President; S. L. Scheffer, Vice-president; L. O. Spencer, Secretary; H. G. Marshall, Treasurer. September 25. Attendance 15.

Talks by D. B. Henderson and L. O. Spencer, Students, on their summer experiences. Professor W. E. Barrows, Jr., Counselor, outlined the N. E. L. A. convention, and described the progress and future possibilities in the field of illumination engineering. October 30. Attendance 20.

Smoker and entertainment. Demonstrations of high-frequency phenomena and Tesla effects. November 20. Attendance 250.

Railway Electrification, by S. L. Scheffer, Student. Professor W. E. Barrows, Jr., Counselor, gave a demonstration of some new illumination equipment received from the General Electric Co. December 11. Attendance 16.

Marquette University

Films—"Blasting the Water Highways of America," and "Hydroelectric Power Production in the New South." December 4. Attendance 22.

Massachusetts Institute of Technology

The Opportunities for the Graduate who Enters Electrical Manufacturing, by C. E. Eveleth, Vice-President, General Electric Co. Dinner preceded the meeting. January 7. Attendance 300.

Michigan College of Mining and Technology

Substations and Their Uses, by E. E. Chilberg, General Electric Co.;

Transformers, by I. E. Devlin, General Electric Co. Illustrated with educational films. December 9. Attendance 31.

University of Michigan

Materials in the Magnetic Circuits of Communication Apparatus, by Dr. Remmers, Western Electric Co. Illustrated with slides showing the characteristics, manufacturing processes, and uses of many magnetic materials. An explanation of the various branches of the Bell System was given by J. T. Schaefer, Michigan Bell Telephone Co. R. A. Price, Western Electric Co., made a few remarks. December 17. Attendance 55.

School of Engineering of Milwaukee

The Story of Electrical Inspection, by Wm. Haig, Head of Electrical Inspection Department of the City of Milwaukee, assisted by Mr. Crickie. December 3. Attendance 41.

Mississippi A. & M. College

J. M. Leigh, Chairman, gave an outline of the various activities at the District Meeting held in Louisville. December 5. Attendance 31.

University of Missouri

Rectox Rectifiers, by Mr. Vincill, Student. January 7. Attendance 23.

Montana State College

Vacuum Tubes, by B. L. Snoddy, General Electric Co. December 4. Attendance 126.

Developing Power from Sea Water, taken from the *Electrical World*, presented by A. J. Hill, Student;

Successful Trolley Bus Operation Demands Suitable Overhead, taken from *Railway Journal*, presented by A. T. Keene, Student;

The Breathing Battery, taken from *Radio World*, presented by H. T. Lambdin Student;

Night Football, taken from *Electrical World*, presented by R. MacDonald, Student;

A New Weather Broadcasting Station in Butte, by Henry Nervobig, Student. December 11. Attendance 130.

University of Nebraska

Professor F. W. Norris, Counselor, gave an illustrated talk, describing the action of the telephone typewriter used by the Bell System. December 17. Attendance 14.

Newark College of Engineering

Double-Wound Generators, by F. W. Gay, Public Service Production Co. December 15. Attendance 28.

Electrical Horology, by W. R. Acker, Chairman. Demonstrated. January 5. Attendance 29.

University of New Mexico

The Vacuum Tube, by S. M. Pelatowski, Student;

The Life of C. P. Steinmetz, by R. Harris, Student. December 17. Attendance 9.

North Carolina State College

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and Vice-president District No. 4, A. I. E. E. Banquet in honor of new members preceded the meeting. December 10. Attendance 60.

Film—"From Coal to Electricity." D. P. Melton, Student, explained the proposed exhibits for the Engineers Fair. January 6. Attendance 40.

University of North Carolina

The Manufacture of Porcelain Insulators, by E. W. Winkler, Instructor;

Pulverized Fuel, by E. R. Davis, Student. November 20. Attendance 41.

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and Vice-president District No. 4, A. I. E. E. December 11. Attendance 80.

Northeastern University

Engineering Ethics, by H. C. Hamilton, Edison Electric Illuminating Co. of Boston. Refreshments were served. December 2. Attendance 49.

University of Notre Dame

Structural Arc Welding, by W. M. Brady, General Electric Co., illustrated with motion pictures and slides.

The Life of Volta, by P. A. Darmody, Student;

The Development of the Incandescent Lamp, by J. B. Strebinger, Student. Patrick Murray, Student, presented the regular engineering news digest. December 9. Attendance 70.

Ohio University

The Photo-Flash Bulb, by William Miller, Student. Film—"Liquid Air." December 15. Attendance 14.

Oklahoma A. & M. College

Two films—"Induction Voltage Regulators," and "The Vacuum Tube Synchronizing Equipment." December 4. Attendance 47.

Relays, by Paul Foster, Student. Illustrated with slides. December 18. Attendance 12.

Oregon State College

Carrier-Current Telephony, by W. R. Deardorff, Pacific Tel. & Tel. Co. W. A. Kleist, of the same company, supplemented Mr. Deardorff's talk. December 9. Attendance 25.

Pratt Institut

Transmission of Pictures by Wire, by Mr. O'Nasch, New York Telephone Co. Illustrated with slides. December 18. Attendance 180.

Princeton University

Magnetic Potentiometers, by R. M. Kime, Student;

The Generation of Steam, by Ernest E. George, Student. December 11. Attendance 10.

Purdue University

The Storage Battery—A Box Full of Problems, by R. J. Kryter, Prest-O-Lite Storage Battery Co. December 9. Attendance 35.

Rensselaer Polytechnic Institute

New General Electric Permanent Magnet Oscillographs, by Claude Hathaway, General Electric Co. December 9. Attendance 130.

University of South Carolina

What is Expected of the College Graduate, by R. E. Brooks, Student;

The Development of Arizona, by W. T. Thomas, Student. December 8. Attendance 40.

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and Vice-President District No. 4, A. I. E. E. December 15. Attendance 125.

Election of officers as follows: L. E. Rankin, Chairman; C. H. Bryan, Vice-chairman; W. Dickerson, Secretary-Treasurer. January 5. Attendance 14.

South Dakota School of Mines

Annual Frolic with entertainment and luncheon. December 16. Attendance 116.

University of Southern California

High-Tension Line Construction, by Clayton M. Allen, Bureau of Power & Light. December 10. Attendance 29.

Southern Methodist University

Ultra Short-Wave Transmission, by J. D. Tucker, Student. December 9. Attendance 21.

Stanford University

Address by Dean Dexter S. Kimball of Cornell University. Joint meeting with the A. S. M. E. Branch. December 9. Attendance 50.

Stevens Institute of Technology

Election of officers as follows: George J. Costello, Chairman; Edmund Starzec, Secretary. General discussion of Branch activities. December 11. Attendance 9.

Film—"The Single Ridge." December 19. Attendance 17.

The Life of Michael Faraday, by Paul H. Beier, Student. January 8. Attendance 30.

Swarthmore College

Discussion of plans for the coming A. I. E. E. Student Convention to be held at Swarthmore College. January 7. Attendance 11.

Syracuse University

The Radio Beacon, by Alex Paterson, Student;

Carrier Current in Telephony, by Chester Grant, Student. December 12. Attendance 25.

The Photoelectric Cell, by Oliver Bigsby, Student;

Television, by Stewart Darrow, Student. December 19. Attendance 25.

Sperry Gyroscopic Stabilizers, by Stanley Scerbinski, Student;

Non-Resonating Transformers, by George Cowell, Student. January 9. Attendance 25.

Texas A. & M. College

Electric Refrigeration, by George Cushman, Student;

Gas Refrigeration, by R. L. Allen, Student. November 24. Attendance 50.

Film—"Oil Circuit Breakers." December 8. Attendance 50.

University of Texas

General discussion and plans made for a banquet meeting. September 23. Attendance 20.

Why I Became a Member of the A. I. E. E., by C. A. Glover, Student. Dinner preceded the meeting. September 29. Attendance 80.

Short talks by Professor J. A. Correll, Counselor, and Lyle Burnham, Student. October 15. Attendance 41.

History of Hydroelectric Development at Austin, Texas, by T. E. Cole, Student. December 11. Attendance 17.

University of Vermont

Properties of Perminvar and Permalloy, by Professor R. O. Buchanan. Illustrated. December 16. Attendance 24.

University of Washington

The Applications of the Photoelectric Cell, by J. Mackay, Student. December 4. Attendance 20.

The Rock Island Development, by Mr. DeMuth, Stone & Webster Engg. Corp. November 20. Attendance 74.

Washington University

Economic Aspects of the Generation of Power, by Professor Roy S. Glasgow. December 11. Attendance 21.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during December are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Sound Waves and Their Uses. By Alexander Wood. Lond. & Glasgow, Blackie & Son, 1930. 152 pp., illus., diagrs., tables, 9 x 6 in., cloth. 7/6.——These six lectures delivered at the Royal Institution give a remarkably readable, well illustrated account of modern development in acoustics. Methods of signaling in air and water, noises, the analysis of sounds, the ear, and the recording and reproduction of sound are discussed. The book is suited to the general reader without previous training, but references are included for those who wish further information.

Acoustics; a Text on Theory and Applications. By George Walter Stewart and Robert Bruce Lindsay. N. Y., D. Van Nostrand Co., 1930. 358 pp., diagrs., tables, 9 x 6 in., cloth. $5.00.——The increasing use of acoustical apparatus has created a need for better understanding of the theory of acoustics. The present book aims to meet the need by providing a clear exposition of the theory, in which modern applications are kept to the fore. The book is intended to provide the equipment necessary for attacking mathematically the problems that confront the designer of telephone equipment, the architect and other investigators.

A Century of Wood Preserving. Edited by Sir Harold Boulton. London, Philip Allan & Co., 1930. 150 pp., plates, 9 x 6 in., cloth. 8/6.——A collection of papers upon wood preservation, especially by creosoting, which form an account of the development of the art during the hundred years that have passed since John Bethell became interested in the subject. Bethell's patent is given in an appendix, and there is a long list of references on wood preservation.

Diesel Power Plant Handbook (formerly the Oil Engine Power Plant Handbook). 6th edition. By Julius Kuttner. N. Y., Diesel Power, 1930. 280 pp., illus., 11 x 8 in., fabrikoid, $5.00. ——The text of this edition consists of a practical course on the operation and maintenance of Diesel engines, which should meet the ordinary requirements of the engine room. In addition the book contains condensed descriptions of the Diesel engine manufacturers of the United States.

Electric Circuit Analysis. By Michel G. Malti. N. Y., John Wiley & Sons, 1930. 389 pp., diagrs., tables, 9 x 6 in., cloth. $4.50.——In this book the author first discusses complex numbers, vectors and the theory of sine functions. The electric units and their dimensions are then studied, after which the characteristics of an electric circuit are explained. The steady and transient phenomena in an electric circuit are then discussed at length. The book represents the course in circuit analysis given at Cornell University.

Electrical Power Transmission and Interconnection. By C. Dannatt and J. W. Dalgliesh. N. Y., Isaac Pitman & Sons, 1930. 424 pp., diagrs., tables, 9 x 6 in., cloth. $7.50.——The bulk transmission of electrical energy has become a major engineering problem, presenting new and wide issues, upon which much scattered literature exists. To obviate the laborious search for this, the authors have attempted to provide a complete introduction to the electrical aspects of power transmission and interconnection. Overhead and underground lines, corona, network theory, line calculations, power and stability, interference, neutrals, and transient voltage phenomena are among the topics treated.

Electricity and Magnetism. By Charles A. Culver. N. Y., Macmillan Co., 1930. 383 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.25.——Intended to give students of the liberal arts a reasonably thorough understanding of the fundamental principles of electricity and magnetism and of their commercial applications.

Flights from Chaos. By Harlow Shapley. N. Y., Whittlesey House; McGraw-Hill Book Co., 1930. 168 pp., 9 x 6 in., cloth. $2.50.——Dr. Shapley here presents his conception of order in the apparent chaos of the universe, and develops a general, complete classification of all material systems, from electrons to the galaxy of galaxies, into a series of classes of ever increasing size and mass. The book is based upon a series of lectures and is addressed to the lay reader.

Hydraulics for Engineers and Engineering Students. By Frederick Charles Lea. 5th edition. N. Y., Longmans, Green & Co., 1930. 775 pp., illus., diagrs., tables, 9 x 7 in., fabrikoid. $7.50.——The new edition of this well-known text-book apparently has been entirely reset, and in the process the accumulated appendices have been incorporated in the text. A considerable amount of material upon recent researches and developments and a chapter on dynamic similarity have been added.

The book offers a clear, practical exposition of the fundamentals of hydraulics, with illustrations of their applications to water wheels, pumps and hydraulic machines, and to the measurement of the flow of water.

Manuale Pratico di Telegrafia Sottomarina. By Italo de Guili. Milano, Ulrico Hoepli, 1931. 384 pp., illus., diagrs., tables, 6 x 4 in., cloth. 30 lire.——A textbook on submarine cable practise for students and operators. The construction of lines and apparatus is described in detail. Theory is reduced to the minimum.

Patent Rights for Scientific Discoveries. By C. J. Hamson. Indianapolis, Bobbs-Merrill Co., 1930. 286 pp., 9 x 6 in., fabrikoid. $5.00.——This monograph, which received the Charles C. Linthicum Foundation prize in 1929, discusses the important new legal idea of "scientific property." The author reviews the historical development of the idea and past attempts to protect the rights of discoverers of scientific facts, and discusses the problems that arise in formulating a law to protect discoverers. The draft of a proposed statute is given and the objections to it discussed.

Starkstromtechnik, vol. 2. Edited by E. V. Rziha and J. Seidener. 7th edition. Berlin, Wilhelm Ernst & Sohn, 1931. 1034 pp., illus., diagrs., tables, 7 x 5 in., cloth. 37.-r. m.——Corresponds in form and character to American "handbooks" of electrical engineering. The present (second) volume covers the production and transmission of electric energy, and its use in mining and agriculture, for hoisting and rolling metals and in factories. The new edition has been thoroughly revised by a number of specialists.

A Study of the Induction Motor. By F. T. Chapman. N. Y., John Wiley & Sons, 1930. 289 pp., illus., diagrs., 9 x 6 in., cloth. $5.50.——Dr. Chapman develops the theory of the induction motor and discusses the characteristics of the various types, using only simple algebra and geometry in his argument.

Theorie der Wechselströme. By Alfred Fraenckel. 3rd edition. Berlin, Julius Springer, 1930. 260 pp., illus., diagrs., 10 x 7 in., bound. 21,50 r. m.——A concise text-book for students of electrical engineering, intended to present the knowledge of alternating-current theory needed by the practical engineer, and to train him in the graphic and analytic methods used to investigate the phenomena of a-c. circuits.

Artificial Sunlight; combining radiation for health with light for vision. By M. Luckiesh. N. Y., D. Van Nostrand

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Co., 1930. 254 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.75. Dr. Luckiesh discusses the need for artificial sunlight, our methods of producing and controlling it, and the fields in which it may be applied. Much physical and biological information is given upon radiant energy, the advantages of the "sunlight lamp" are explained and compared with those of other sources of ultraviolet rays. Practical methods of dual-purpose lighting are discussed.

BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES AND GAS ENGINEERING AND APPLIANCE CATALOGUE. 1930. N. Y., Robbins Publishing Co., 1930. 284-369 pp., illus., 12 x 9 in., cloth. $15.00.——As in previous editions, we find here the gas statistics of the companies supplying manufactured and natural gas in North America and of the holding and operating companies in the continent. The members of public service commissions are also listed, and the officers and members of gas associations. In addition the volume contains condensed catalogs of manufacturers of gas equipment and supplies. The statistics are revised to date and include those ordinarily wanted.

◆

Selected Items *From*

Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Arcs

ALTERNATING CURRENT. Supply of Electric Arcs with Alternating Current (Considérations générales sur l'alimentation des arcs a courant alternatif), A. de Stavraky. *Revue d'Electricité et de Mécanique (Paris)*, no. 13, Sept.-Oct. 1930, pp. 10-11, 3 figs. Equipment derived from P. Boucherot's and J. Berthenod's suggestions is reviewed; remedies for instability and for improvement of power factor are suggested; the theoretical study of these apparatus are given in same number of journal.

Brakes

ELECTRIC. New Methods of Approach for Explanation and for Improving Results in Braking of Street Railroad Cars (Neue Wege zur Klaerung der Vorgaenge und zur Verbesserung der Ergebnisse bei der Bremsung von Strassenbahnwagen), R. Boehm. *Verkehrstechnik (Berlin)*, no. 47, Nov. 21, 1930, pp. 625-630, 18 figs. Present electric braking equipment of Nuernberg-Fuerth line and results obtained; relation between maximum and average braking retardation; influence of slipping and sanding, cinematographic-oscillographic method of research; improved braking results.

Cables

ALUMINUM. Aluminum in Armoured Electric Cables (L'aluminium dans les cables electriques armes). *Radioélectricité et QST Francais (Paris)*, vol. 11, no. 81, Dec. 1930, pp. 28-30, 4 figs. Composition, conductor material, insulation resistance, disruptive strength; excessive voltages and currents, laying qualities; comparison between copper and aluminum conductors from economical standpoint, armoring.

LEAD SHEATHING. Flow Characteristics of Some Lead Cable Sheath at Temperatures Above Atmospheric, O. L. Clark and C. Upthegrove. *Fuels and Steam Power (A. S. M. E. Trans.)*, vol. 52, no. 27, Sept.-Dec. 1930, pp. 249-254, 16 figs. Paper previously indexed from Advance Paper, no. 1, for mtg. June 9-12, 1930.

OIL FILLED. 75-Kv., Three-Conductor, Oil-Filled Cable, E. F. Nuezel. *Elec. World*, vol. 96, no. 24, Dec. 13, 1930, pp. 1088-1092, 16 figs. Union Gas & Electric Co. has taken step forward in oil-filled cable field with recent installation at its Columbia station; cable is first installation of 75-kv. three-conductor, shielded conductor type, oil-filled cable in this country; many features in design of cable and its accessory equipment are entirely new and original developments of General Electric Co. to meet particular requirements of installation.

SPLICING COMPOUNDS. Tentative Methods of Testing Cable Splicing and Pothead Compounds. *Am. Soc. Testing Metals.—Tentative Standards*, 1930, pp. 564-570, 2 figs. Methods cover: physical tests; dielectric strength test and coefficient of expansion.

TELEPHONE, SUBMARINE. Two-Band Communication from Helgoland to Cuxhaven and Hamburg (Zweibandsprechen von Helgoland nach Cuxhaven und Hamburg), W. Weinitschke. *Telegraphen und Fernsprech Technik (Berlin)*, vol. 19, no. 10, Oct. 1930, pp. 310-312, 6 figs. Use of 80 km. telephone telegraph cable which had become overloaded with traffic is now used for two band carrier current telephony which has brought solution and satisfactory results; measurements; curves.

Canals

ELECTRIC EQUIPMENT. The Electrical System of the Welland Ship Canal, A. L. Mudge, L. P. Rundle and F. A. Pankhurst. *Elec. News (Toronto)*, vol. 39, no. 22, Nov. 15, 1930, pp. 49-86, 63 figs. Description of power house, step-up transformer station, transmission line, substations, lock distribution system, motors and control equipment, lock operation, signals, bridges, lighting, heating, telephones, standardization, foreign cable crossings and gate lifter.

Car Lighting

Electric Train Lighting on Secondary Railroads (l'eclairage electrique des trains de chemins de fer secondaries), Vincent. *l'Industrie des Voies Ferrées et des Transports Automobiles (Paris)*, vol. 24, no. 286, Oct. 1930, pp. 278-282, 6 figs. Review of relative merits of various equipment and makes with particular regard to systems using battery and generator driven from axle, including Systeme E. V. R., Systeme Brown-Boveri.

Ceramic Kilns

ELECTRIC. Electric Heat for Ceramic Kilns, J. T. Jans. *Ceramic Age*, vol. 16, no. 6, Dec. 1930, pp. 326-327 and 330, 1 fig. Characteristics of high and low temperature kilns. Paper presented before New Jersey Clay Workers Assn., Oct. 1930.

Circuit Breakers

OIL. Oil Circuit Breaker Design. *Elec. Times (Lond.)*, vol. 78, no. 2039, Nov. 20, 1930, pp. 885-887, 5 figs. Phenomena of arc rupturing with special reference to the R type oil circuit breaker of Ferguson, Pailin, Ltd.

SPEED CHARACTERISTICS. Circuit-Breaker Duty Affected by Speed, O. L. Denault. *Elec. World*, vol. 96, no. 20, Nov. 15, 1930, pp. 913-915, 5 figs. When circuit is opened by breaker voltage recovers; circuit characteristics determine rate of voltage recovery; delayed recovery promotes deionization, less arc length, time and energy.

Clocks

ELECTRIC. Clocks and Apparatus with Synchronous Motor, A. Rabinowitsch. *AEG Progress (Berlin)*, vol. 6, no. 12, Dec. 1930, pp. 374-378, 12 figs. Advantages of electric clocks and other control apparatus equipped with synchronous motors.

Coal Mines

ELECTRIC DRIVE. Electric Drives for Main Shaft Ventilators (Die elektrischen Antrieb fuer Hauptschachtluefter), K. Schade. *Elektrizitaet im Bergbau (Munich)*, vol. 5, no. 11, Nov. 15, 1930, pp. 205-216, 25 figs. Determination of required power and details of drive; regulatable drives; wiring diagrams of various combinations and systems; equipment described and illustrated. (To be continued.)

ELECTRIC EQUIPMENT. Power Consumption, Output, and Economy of Electric Haulage Equipment and Coal Cutters in Underground Coal Mining (Energieverbrauch, Leistung und Wirtschaftlichkeit der elektrischen Abbaufoerdereinrichtungen und Schraemmaschinen im untertaegigen Steinkohlenbergbau), E. Meyer. *Elektrizitaet im Bergbau (Munich)*, vol. 5, no. 10, Oct. 10, 1930, pp. 185-203, 16 figs. Results of measurements on equipment of various types are summarized in curves and tables.

Commutators

High Speed Commutators, B. Bonnell. *Elec. Times (Lond.)*, vol. 78, no. 2037, Nov. 6, 1930, pp. 791-792, 4 figs. Suggestions for manufacture of high-speed commutators of "V" ring construction.

Condensers

POWER FACTOR IMPROVEMENT. Electric Power Condensators for Reactive Current Compensation and their Economy in Industrial Installations (Starkstrom-Kondensatoren zur Blindstrom-Kompensation und ihr Wirtschaftlichkeit in Industrieanlagen), H. Cypra. *Elektrizitaet im Bergbau (Munich)*, vol. 5, no. 11, Nov. 15, 1930, pp. 216-219, 6 figs. Condensers are recently favored over rotating equipment because of low internal losses and simple and safe installations; features are described and equipment of AEG illustrated; internal loss curves are given in accordance with reactive load.

Conductors

Propagation of Electricity Through Conducting Wire (Propagation de l'électricité dans un fil conducteur), J. Granier. *Radioélectricité et QST Francais (Paris)*, vol. 11, no. 81, Dec. 1930, pp. 6-9, 1 fig. Theoretical mathematical analysis in which all line characteristics are considered, discussing also various practical cases as for instance, series equation showing potential distribution along line, application to submarine and underground cables, etc.

RESISTANCE. Ohmic Resistance of Copper Conductors at High Frequency (Résistance ohmique des conducteurs en cuivre en haute fréquence), M. Mathieu. *Arts et Métiers (Paris)*, vol. 83, no. 122, Nov. 1930, p. 450, 1 fig. Curve gives values of constants for conductors from 0.1 to 10 mm. at frequencies from 10 to 300,000 kilocycles.

STRENGTH. Stretch of Wire Cables (Die Dehnungsarbeit am Seilen), J. Groebl. *Elektrotechnische Zeit. (Berlin)*, vol. 51, no. 49, Dec. 4, 1930, pp. 1669-1673, 6 figs. Investigation mainly refers to wire cables used in electric transmission lines; notes on torsion as factor of stretch; number of torsions as function of tensile strength; equation of torsion curve in over proportional range; calculation of torsional stretch; normal stretch equation; calculation of fictive elasticity modulus. (To be concluded.)

Conductivity

ELECTRIC. Recent Studies of Supraconductivity (Neue Untersuchungen ueber Supraleitfaehibkeit). *Zeit. fuer die gesamte Kaelte-Industrie (Berlin)*, vol. 37, no. 11, Nov. 9, 1930, pp. 218-220. Report on works of W. J. de Haas, E. van Aubel and T. Voogd; investigation to determine change in conductive characteristics of combination of supraconductor with non-supraconductor to alloy; reference is made to experiments in Leiden and Toronto.

Cranes

ELECTRIC. Improved Electrical Crane Equipment, B. Erenyi. *AEG Progress (Berlin)*, vol. 6, no. 12, Dec. 1930, pp. 372-373, 3 figs. Improvements described are "telegraphing" system of switching (tap control) and two-speed crane motor.

Dielectrics

ELECTRIC CONDUCTIVITY. The Conduction of Electricity in Liquid Dielectrics, D. H. Black and R. H. Nisbet. *Lond., Edinburgh, and Dublin Philosohpical Mag. and Jl. of Science (Lond.)*, vol. 10, no. 66, Nov. 1930, pp. 842-861, 11 figs. Possibility of applying theory of conduction in gases to conduction in liquid dielectrics is investigated; gas theory is considered as leading to distribution of internal resistances, and is shown to be special case of general theory advance in previous paper which attributed fall of current usually known as "absorption" to formation of internal resistances. Bibliography.

Diesel-Electric Plants

COSTS. Economics of the Use of Diesel Engines for Electric Power Generation, T. A. Burdick. *Oil and Gas Power (A. S. M. E. Trans.)*, vol. 52, no. 25, Sept.-Dec. 1930, pp. 65-74, 3 figs. Abstract of paper presented before Am. Soc. Mech. Engrs., previously indexed from Power, Sept. 16, 1930.

DESIGN. Further Refinement Characterizes Diesel Power. *Power Plant Eng.*, vol. 34, no. 24, Dec. 15, 1930, pp. 1425-1428, 3 figs. Refinement of engine construction, increase in use of auxiliary equipment, and improved plant management increase reliability of Diesel power; Diesel-plant data covering five central stations, six municipal plants, and five industrial applications; Diesel-engine data.

Electron-Theory

METALS. Some Recent Advances in the Electron Theory of Metals, R. H. Fowler. *Instn. Elec. Engrs.—Jl. (Lond.)*, vol. 68, no. 467, Nov. 1930, pp. 1469-1475, 3 figs. Nature of metal and classical theory; quantum mechanical revision; new conduction theory; thermoelectric effects; emission of electrons; magnetism and ferromagnetism; Kapitza's experiments on conductivity in strong magnetic fields.

Education

ENGINEERING. Summary of the Study of Technical Institutes, W. F. Wickenden. *Mgmt. (A. S. M. E. Trans.)*, vol. 52, no. 26, Sept.-Dec. 1930, pp. 63-69 and (discussion) 69-72. Previously indexed in Engineering Index 1929, p. 756, from Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Dec. 2-9, 1929.

Broadening Effects of Engineering Education Demonstrated by Statistics, D. B. Prentice. *Mech. Eng.*, vol. 52, no. 12, Dec. 1930, pp. 1102-1103. Carnegie Foundation for Advancement of Teaching is making Elaborate study of secondary and collegiate education in Pennsylvania; important part is comprehensive examination in all fields of knowledge to measure content of students' minds; in spite of fact that more than half college course for engineers was devoted to professional subjects and many more hours to fundamental sciences, seniors possessed breadth of knowledge sufficient to score much higher in fields not their own than arts men.

Electric Circuits

Early Developments in A. C. Circuit Theory; Some Notes on the Application of Complex Methods to the Solution of A. C. Circuit Problems, G. Windred. *Lond., Edinburgh, and Dublin Philosophical Mag. and Jl. of Science (Lond.)*, vol. 10, no. 66, Nov. 1930, pp. 905-914. Neglect of theory in England is pointed out; theoretical mathematical analysis. Bibliography.

THREE-PHASE. Protection and Metering for Three-Wire Circuits, J. Auchincloss. *Power Plant Eng.*, vol. 34, no. 23, Dec. 1, 1930, pp. 1363-1366, 13 figs. Methods of locating faults in various circuits; two-phase five-wire with common protection; metering three-phase, three-wire and two-phase, four-wire power on one three element meter. (Concluded.)

Electric Discharge

NEON. Discharges in Neon, P. Johnson. *Lond., Edinburgh, and Dublin Philosophical Mag. and Jl. of Science (Lond.)*, vol. 10, no. 66, Nov. 1930, pp. 921-931, 4 figs. Following on researches which have been made at Electrical Laboratory, Oxford, on electric forces required to maintain high-frequency discharges in certain gases, author has undertaken measurement of these forces in neon.

TUBE FAILURE. A Note on the Fracture of Discharge-Tubes, R. H. Sloane. *Lond., Edinburgh, and Dublin Philosophical Mag. and Jl. Science (Lond.)*, vol. 10, no. 67, Dec. 1930, pp. 1099-1102, 1 fig. While investigating conditions of excitation near cathode of glow discharge in argon, inconvenience was experienced from frequent spontaneous failure of tubes, where discharges of only 2 milliamperes at 400 volts wire passed; apparently it is due partly to use of argon, which, as is well known, gives rise to heavy cathodic sputtering, but mainly to fact that design of tubes involved contact of cathode with walls.

Electric Furnaces

Electric Melting and Heating of Metals, W. S. Gifford. *Metal Industry (Lond.)*, vol. 37, no. 21, Nov. 21, 1930, pp. 481-484, 4 figs. Review of development and use of principal types of furnaces; Ajax Wyatt furnaces; arc furnaces; induction furnaces; high-frequency induction furnaces; refractory linings; resistance furnaces; factors controlling efficiency and operation with various metals. Paper read before mtg. of Manchester Assn. Engrs.

ANNEALING. Annealing Furnaces in the Metal Industry, Especially Modern Electric Furnace (Gluehoefen; besonders die neueren elektrischen, in der Metallindustrie), B. Schulz. *Brennstoff- und Wacrmewirtschaft (Halle)*, vol. 12, no. 17-18, Sept. 1-2, 1930, pp. 217-218, 2 figs. Electric annealing and heat-treating furnaces; equipment for heat-treating metal tubes and annealing of hoops, sheets, and wires.

HIGH FREQUENCY. Alloy Steel Melting in the Induction Furnace, O. Doerrenberg and N. Broglio. *Metallurgist (Supp. to Engineer, Lond.)*, Nov. 1930, pp. 166-167. Installation built at Ruenderoth has been in continuous day and night use, and at time of writing has been responsible for more than 1200 melts; furnace is energized by means of special generator capable of maintaining 1200 volts at frequency of 2000 cycles per sec.; tapered form of crucible has been adopted in spite of deliberate sacrifice of electrical energy implied by its use. Translated abstract of paper previously indexed from Stahl und Eisen, May 8, 1930.

Which do You Prefer?

LAST month we presented 73 of these references to current engineering literature, using large type; this month we present 115 items, using smaller type.

WHICH serves your purposes best? A PROMPT note to the Editor will be appreciated and will help to improve this reference service.

INDUCTION. Electrical Apparatus for the Coreless Induction Furnace, N. R. Stansel. *Iron and Steel Engr.*, vol. 7, no. 11, Nov. 1930, pp. 519-524, 15 figs.

Furnaces and accessories of 50 kw. and over are described in some detail; efficiency and temperature resistivity curves are given.

STEEL MAKING. High-Frequency Furnace Produces Pure Steel, K. Hohage and B. Matuschka. *Steel*, vol. 87, no. 24, Dec. 11, 1930, pp. 55-56. Type of furnace used by Schoeller-Bleckmann Steel Works, Vienna, Austria, has melting crucible made of acid refractory with coil wound around it; direction of current in coil is changed 3000 times per sec.; current is generated in separate high-frequency converter.

TRANSFORMERS. Transformers for Electric Furnaces (Les transformateurs pour fours électriques), G. Marty. *Jl. du Four Electrique (Paris)*, vol. 39, no. 10, Oct. 1930, pp. 378-380, 3 figs. Special characteristics, wiring diagrams of supply transformers with three regulating taps, one for continuous regulation. (To be continued.)

Electric Heating

MATERIALS. Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 133-151, 2 figs. Outline of method covers; solutions required, determination of chromium, determination of manganese, determination of carbon, determination of insoluble residue, determination of silicon, determination of sulphur, determination of copper.

Electric Lines

ICE FORMATION. Currents Required to Remove Conductor "Sleet," J. E. Cl m. *Elec. World*, vol. 96, no. 23, Dec. 6, 1930, pp. 1053-1056, 3 figs. Formula and alignment charts for calculating of preventing formation of ice; amperes required to prevent ice formation; current and temperature required to prevent sleet adherence; current and time required to melt ice; amperes required to melt off glaze.

Floodlighting

Short Cuts to the Solution of Floodlighting Problems, H. E. Butler. *Gen. Elec. Rev.*, vol. 33, no. 12, Dec. 1930, pp. 690-698, numerous figs. partly on supp. plate. Comments upon scope and tend of modern floodlighting; data for computation of floodlighting installations; sample problems; typical installations; summary of requirements; chart of floodlighting data and characteristics; partial list of athletic fields lighted with General Electric equipment.

Generators

ALTERNATING CURRENT. Flywheel Type Alternators in the Tropics, J. Finkelstein. *AEG Progress (Berlin)*, vol. 6, no. 12, Dec. 1930, p. 358, 1 fig. Description of AEG 860 kva., 6600 volt alternator for Dutch East Indies power station, Magelang, Java to work with airless injection 975 hp., 214 r. p. m., 6-cylinder 4-stroke cycle Diesel engine made by Messrs. Gebr. Sulzer, Winterthur.

Hydroelectric

POWER DEVELOPMENTS. Hydroelectric Utilizations in Irrigation Projects (Los Aprovechamientos Hidroelectricos en los Proyectos de Irrigacion), J. Herrera y Lasso. *Irrigacion en Mexico (Mexico, D. F.)*, vol. 1, no. 1, May 1930, pp. 22-26, 2 figs. How power development affects financing of irrigation systems; factors in study of probable power markets.

Illuminating Engineering

TERMINOLOGY. Revision of the American Standard Illuminating Engineering Nomenclature and Photometric Standards. *Illum. Eng. Soc.—Trans.*, vol. 25, no. 8, Oct. 1930, pp. 725-741. Activities and duties of Society's Committee on Nomenclature and standards; standard nomenclature, as revised to present time, is given.

Industrial Plants

ELECTRIC POWER. Economical Control of Purchased Electrical Power in the Industrial Plant, R. F. Gale. *Iron and Steel Engr.*, vol. 7, no. 21, Nov. 1930, pp. 536-537, 5 figs. Methods of obtaining high load factors by proper coordination of purchased and manufactured power used by Midvale Co., Philadelphia; day load peak 7500 kw. is approximately 3500 kw. greater than night load peak 4000 kw.

Insulating Materials

PAPER. Tentative Methods of Testing Untreated Insulating Paper. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 571-589, 7 figs. Methods apply to untreated paper which is to be used as electrical insulator or as constituent of composite material used for electrical insulating purposes.

Properties, Tests and Applications of Papers in Electrical Industry (Propriétés, essais et applications des papiers en électrotechnique), A. R. Matthis. *Chimie et Industrie (Paris)*, Mar. 1930, (special no.) pp. 445-451. Properties required of such papers are briefly outlined, together with various tests to which they are subjected.

SLATE. Tentative Methods of Test for Determining the Insulating Qualities of Slate. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 524-526. Method A covers determination of impedance leakage current flowing in high-voltage winding of transformer by means of ammeter in low voltage winding; method B covers determination of impedance leakage current flowing in high-voltage winding of transformer or specific ohmic impedance of slate by reading two voltmeters in low-voltage circuit.

TESTING. Tentative Methods of Testing Laminated Sheet Insulating Materials. *Am. Soc. Testing Matls.—Tentative Standards,* 1930, pp. 590-597, 1 fig. Tests apply to laminated flat sheet materials intended for use as electrical insulation.

Insulators

OIL-RESIN. Study of Electric Behavior of Oil-Resin Compounds with Special Regard to Range of Relatively Low Temperatures (Untersuchung ueber das dielektrische Verhalten von Oel-Harzimschungen unter besonderer Beruecksichtigung des Bereiches relativ geringer Temperaturen), E. Jirch and W. Riebel. *Archiv fuer Elektrotechnik (Berlin),* vol. 24, no. 4, Nov. 7, 1930, pp. 553-560, 11 figs. Relation between dielectric constants, angle of error and viscosity in range from 0 to 150 cent. at relatively low temperatures; phenomena are studied on theory of polar molecules of Debye.

PORCELAIN. Electrical Porcelain, J. K. Gillett. *Elecn. (Lond.),* vol. 105, no. 2737, Nov. 14, 1930, pp. 588-589, 5 figs. Tests for porosity; effect of glazes on mechanical and thermal properties; breakdowns caused by cementing. Bibliography. (Concluded.)

SPECIFICATIONS. British Standard Specifications for Porcelain Insulators for Overhead Power Lines. *Brit. Eng. Standards Assn.—Specifications (Lond.),* no. 137, 1930, 29 pp., 6 figs. Specification is applicable to porcelain insulators for overhead power lines at declared voltages and station voltages of 3 and 3.3 kv. respectively and upwards.

SUSPENSION. Suspension Insulators (Quelques remarques sur les isolateurs suspendux), Lequerier. *Société Belge des Electriciens—Bul. Mensuel (Brussels),* vol. 46, Nov. 1930, pp. 556-588, 10 figs. Comparison of types, characteristics, notes on testing and testing equipment, strength curves, high tension testing, arcing protection, etc.

TESTING. The European Insulator Situation, T. Rich. *Elec. Times (Lond.),* vol. 78, nos. 2037, 2039 and 2040, Nov. 6, 1930, pp. 787-788, Nov. 20, pp. 883-884, and Nov. 27, pp. 929-932, 14 figs. Notes on recent developments and in testing laboratories in particular; routine testing department and articles of equipment of two million volt laboratory of Rosenthal Works in Bavaria, previously indexed from various sources.

Lamps

GLOW. Gas Discharge Tubes in Television Practise (Die Gasentladungsroehren in der Fernsehtechnik), H. Ewest. *Fernsehen (Berlin),* vol. 1, no. 2, Feb. 1930, pp. 59-62, 3 figs. Characteristics of inertia free glow lamps and their suitability for television purposes outlined in general way; various types.

The Glow Lamp as Television Light Relay (Die Glimmlampe als Fernseh-Lichtrelais), F. Kirschstein. *Fernsehen (Berlin),* vol. 1, no. 11-12, Nov. 1930, pp. 495-501, 8 figs. Hysteresis of glow lamp is discussed; dynamic and static characteristic; a. c. characteristics, measurement of hysteresis; a. c. resistance as function of frequency; control of glow lamp by output tube, etc.

MANUFACTURE. Some Recent Developments in Lamp Manufacturing, J. A. Jones and E. I. Morwick. *Elec. News (Toronto),* vol. 39, no. 22, Nov. 15, 1930, pp. 39-40 and 48, 4 figs. Combination of ultra-violet and visible radiation gives promise of developing new era of lighting for health maintenance and general illumination; development of S-1 lamps, science has successfully limited wavelengths, shorter than those usually found in sunlight; cut-off in natural sunlight is about 2800 A; spectrum of radiation, bulb transmission and response curves are given. (Concluded.)

Lighting

INDUSTRIAL. Current Industrial Lighting Practise, R. B. Brown, Jr. *Illum. Eng. Soc.—Trans.,* vol. 25, no. 8, Oct. 1930, pp. 716-724. Data and other information calculated to show modern trends in industrial lighting practise; facts and figures have been supplied by several lighting equipment manufacturers and illuminating engineers covering such items as variation in reflector sizes over period of years, as well as distribution of lamp sizes and types of reflector equipment most commonly used; present practise is shown from data supplied by several central-station lighting service engineers from which several definite conclusions are drawn.

VISION RELATIONSHIP. Lighting Plus Vision Equals Seeing, M. Luckiesh and F. K. Moss. *Illum. Eng. Soc.—Trans.,* vol. 25, no. 9, Nov. 1930, pp. 807-824 and (discussion) 824-825, 5 figs. Further attempts to interpret data on various relationships of fundamental factors of vision into lighting practice; scientific basis of satisfactory demonstrations of influence of lighting upon seeing is discussed and successful demonstrations are described and illustrated; various papers by authors represent series beginning with purely scientific data and proceeding, step by step, toward lighting practice.

Loud Speakers

Loudspeakers, S. G. Brown. *Elecn. (Lond.),* vol. 105, no. 2741, Dec. 12, 1930, p. 749. Critical discussion of paper on "Loudspeakers" Since Their Conception with Gramophone Pick-ups and Wireless Recording Apparatus, presented before Inst. Elec. Eng. Great Britain, in London.

An Efficient Loud Speaker at the Higher Audible Frequencies, L. G. Bostwick. *Acoustical Soc. Am.—Jl.,* vol. 2, no. 2, Oct. 1930, pp. 242-250, 5 figs. Purpose of this paper is to describe loud speaker by which it has been possible to obtain efficient radiation of these very high frequencies; this loud speaker is intended for use as adjunct to either baffle or horn type loud speakers to extend range of efficient performance to 11,000 or 12,000 cycles.

ELECTROSTATIC. Theory of the Electrostatic Loud Speaker, C. R. Hanna. *Acoustical Soc. Am.—Jl.,* vol. 2, no. 2, Oct. 1930, pp. 143-149, 2 figs. It is proved that force per unit voltage in electrostatic device is similar function of capacity and negative stiffness due to steady electrostatic field; new concept called Motional admittance is introduced for electrostatic loud speaker and this is shown to be similar in its mathematical form to Motional Impedance of electromagnetic driver; calculation of ultimate theoretical efficiency that may be obtained with electrostatic speaker having pure resistance radiator and covering given frequency range is given.

MEASUREMENT. Loud Speaker Sound Pressure Measurements, E. W. Kellog. *Acoustical Soc. Am.—Jl.,* vol. 2, no. 2, Oct. 1930, pp. 157-200, 18 figs. General test conditions and precautions; comparison of loud speaker system with direct listening; standing wave patterns; compensation for selective absorption in room; advantages of directive loud speakers; test information required to estimate merit; free space measurements; indoor test; moving microphone system; warble method; rapid frequency change method; close up tests; measurements of total output; experimental results; additional data needed; pressure and velocity in neighboroood of small simple source.

Magnetic Measurements

UNITS. New Electromagnetic Unit; One Oersted (En Ny Elektromagnetisk Enhed: En Oersted), A. W. Marke. *Ingenioren (Copenhagen),* vol. 39, no. 45, Nov. 8, 1930, pp. 537-539, 1 fig. International Electrotechnical Commission, in meeting at Copenhagen in June 1930, approved new absolute unit for intensity of field and called it "one oersted;" events leading up to this decision and physical definition of unit.

Remarks on the Decisions of International Electrical Commission with Regard to Magnetic Units (Observations sur les décisions de la Commission électrotechnique internationale concernant les unités magnétiques), E. Brylinski. *Revue Générale de L'Electricité (Paris),* vol. 28, no. 19, Nov. 8, 1930, pp. 722-725. Author concludes that reserves made by Kennelly with respect to use of prefix "Pra" for practical units are without ground as units so characterized can leave no room for doubt.

Metering

The Metering of Three-Phase Supplies, O. Howarth. *Instn. Elec. Engrs.—Advance Paper,* 1930, 13 pp., 13 figs. Large bulk supplies are most complex and demand high standard of accuracy for commercial reasons; unfortunately, each additional complexity introduces additional source of error, and inaccuracies introduced by auxiliary apparatus and special fitments are discussed.

Meters

Summation Metering Equipment. *Engineer (Lond.),* vol. 150, no. 3908, Dec. 5, 1930, pp. 628-629, 6 figs. Ferranti equipment is described: diagram shows equipment required for summation metering of complete station having two-way transformer circuits, three generators, and station auxiliary machine; mechanism consists of two-way contactor driven by auxiliary spindle geared to main meter spindle, and is fitted with heavy silver contacts moved positively in each direction by jewelled rollers bearing on cam.

FREQUENCY. A New Frequency Meter, C. L. Lipman. *Elec. Rev. (Lond.),* vol. 107, no. 2763, Nov. 7, 1930, pp. 793-794, 4 figs. New deflectional-type instrument for measurement of power frequencies.

Mining

ELECTRIC EQUIPMENT. New Mining Electrical Control Gear. *Engineer (Lond.),* vol. 150, no. 3905, Nov. 1930, pp. 546-547, 8 figs. For use in mines, Metropolitan-Vickers Electrical Co., has introduced some new control gear, including self contained controller; mining switch units, also supplied as gate end boxes and mining transformer units; and plug distribution boxes.

ELECTRIC HAZARDS. Selected List of Bureau of Mines Publications Covering Safety Studies and Activities of the Electrical Section, L. C. Ilsley. *Coal Min.,* vol. 7, no. 10, Oct. 1930, pp. 489-491. Previously indexed from U. S. Bur. Mines—Information Cir., no. 6310, July 1930.

Motors

INDUCTION. Motor Selection Improves Power Factor, L. F. Leurey. *Elec. West,* vol. 65, no. 6, Dec. 1, 1930, pp. 292-295, 3 figs. Conclusions are that induction motors should be selected with highest possible speed consistent with practical gear reduction; and operated at highest possible percentage of rated capacity; this especially applies to wound rotor motors intended for variable speed operation.

INDUCTION—STARTING. Use of Induction Motors with Short Circuited Rotor (Sur l'emploi des moteurs asynchrones en court-circuit), J. Le Monnier. *Revue Générale de l'Electricité (Paris),* vol. 28, no. 20, Nov. 15, 1930, pp. 771-779, 9 figs. Squirrel cage motor is only one case of short-circuited rotor type; starting of Boucherot double cage motor; starting of simple motor; experimental verification of starting characteristics; starting current diagrams; braking; influence of power factor; starting by insertion of resistance or inductance in stator circuit.

SYNCHRONOUS. Synchronous Motors, A. H. v. Altmann. *AEG Progress (Berlin),* vol. 6, no. 12, Dec. 1930, pp. 366-371, 4 figs. Characteristics of synchronous motors; overload and fluctuations in torque; network voltage fluctuations; network frequency fluctuations; advantages over other machines; starting methods.

Networks

INTERCONNECTED. Power Flow Studies in Interconnected Systems, P. B. Juhnke. *Gen. Elec. Rev.,* vol. 33, no. 12, Dec. 1930, pp. 670-673, 6 figs. For purpose of helping such study, series of diagrams were constructed for Chicago District for different periods and seasons of immediate years ahead, and for peak periods even decade in advance; four systems involved are operating as one system, by virtue of Interchange Energy Contract, and comprise what is commonly known as Chicago Regional System.

STABILITY. Power-System Stability, R. D. Booth and O. G. C. Dahl. *Gen. Elec. Rev.,* vol. 33, no. 12, Dec. 1930, pp. 677-681, 1 fig. Comprehensive and non-mathematical review of stability problem; review of general problem of power-system stability in light of present knowledge; aspects which still are in controversial and unsettled state as, for instance, effect of damper windings, and influence of various methods of grounding high-tension neutral points. (To be continued.)

Power Factor

CORRECTION. Improvement of Power Factor. *Elec. Times (Lond.),* vol. 78, no. 2040, Nov. 27, 1930, pp. 937-939, 7 figs. Use of electrostatic condensers for correction of low power factors.

Power Generation

Balance Between the Supply and the Consumption of Energy, R. W. Miller. *Elec. Engr. of Australia and New Zealand (Melbourne),* vol. 7, no. 7, Oct. 15, 1930, pp. 235-240, 2 figs. Main factors which affect cost of electrical energy and means that can be adopted to effect economies; basic problem arises from fact that electricity cannot be stored, and therefore various expedients have to be adopted in adjusting supply to cope with demand; it is shown how hydroelectric storage plants may be used to level up demand on base load stations; modern developments in steam power station practice. (To be concluded.)

Power Industry

Congress of the International Association of Producers and Distributors of Electric Power in Brussels, September 1930 [Congrès de Bruxelles de l'Union internationale des Producteurs et Distributeurs d'Energie électrique (Septembre 1930)]. *Revue Générale de Electricité (Paris)*, vol. 28, nos. 20 and 21, Nov. 15, 1930, pp. 765-770 and Nov. 22, 1930, pp. 803-812. Discussions on reported improvements in equipment of thermal generating stations in Belgium, Argentina and Italy; interconnection of metallurgical plants in Briey region; unification of frequencies; smoke abatement, etc.

Power Supply

RURAL. The Status of Research in Rural Electrification, G. W. Kable. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 705-707. Since beginning of organized research in 1923, 24 states have undertaken investigational programs; primary purpose of these surveys has been to learn something of use, demand, cost, and value of electric service on farm, and fundamental difficulties involved in extension of this service; in order to have satisfactory uses for electricity on farm.

Photoelectric Cells

Photo-electric Cells, T. Thorne Baker. *Elec Rev. (Lond.)*, vol. 107, no. 2763, Nov. 7, 1930 pp. 768-769, 3 figs. Circuit with one-valve amplification; bridge circuit for lamp photometry; automatic lighting controller. (Concluded.)

SELENIUM. The Selenium Cell; its Properties and Applications, G. P. Barnard. N. Y., Richard R. Smith, Inc., 1930, 331 pp., illus., diagrs., $9.00. Valuable monograph aims to present precise, accurate survey of knowledge of properties of selenium and of applications of selenium cells to photophony, television, talking films and other practical uses; scattered literature has been very thoroughly summarized and exhaustive bibliography is included in book, which will be found most useful by all workers in this field. Eng. Soc. Lib., N. Y.

Power Plants

PEAK LOADS. Storing Power for Peak Loads, W. H. Onken, Jr. *Nat. Elec. Light Assn.—Bul.*, vol. 17, no. 12, Dec. 1930, pp. 759-761 and 800, 4 figs. Practices of European electric power system in utilizing stored steam and pumped water for auxiliary power during peak loads or in emergencies.

STEAM AND DIESEL. Diesel Power—With Steam Combination. *Power*, vol. 72, no. 22, Nov. 25, 1930, pp. 842-845, 3 figs. Diesel hook-ups shown range from simplest to more complex, former being more typical of current practice; for given power output diesel receives and rejects less heat; however, methods and equipment for conserving waste heat are available wherever economic conditions justify their use.

STEAM AND HYDROELECTRIC. Steam and Hydro Combined for Power and Process. *Power*, vol. 72, no. 21, Nov. 18, 1930, pp. 786-790, 5 figs. Dalhousie plant of New Brunswick International Paper Co. is typical of interrelation of water-power development and paper industry in Canada; 6000-kw. steam turbine and 425-lb. boilers for process steam and emergency service insures reliable operation of 570-ton paper mill when hydro power is obtained over single 110-mi. transmission line; sectional elevation and principal equipment in power plant.

Railroads

POWER SUPPLY. Supply Lines for Single Phase Railroads (Speiseleitungen von Einphasenbahnen), E. Wist. *Elektrotechnik und Maschinenbau (Vienna)*, vol. 48, no. 43, Oct. 26, 1930, pp. 970-972, 1 fig. Analysis of requirements and economical relations between plant, lines and networks; numerical example of 100 kv. line of 240 sq. lines and networks; numerical example of 100 kv. 100 km. line of 240 sq. mm. cross-sectional area for 33,000 kw.

SUBSTATIONS. Omaha Changes Power System To Raise Speed. *Traction Shop and Roadway*, vol. 3, no. 11, Nov. 1930, pp. 327-329, 4 figs., see also *Elec. Traction*, vol. 26, no. 11, Nov. 1930, pp. 566-568, 4 figs. Installation of nine automatic substations, installed throughout system of Omaha and Council Bluffs street railway, eliminate steam power plant, retire old cars and raise average car speed.

Rectifiers

COPPER OXIDE. Copper Oxide Rectifiers, K. Singh and I. R. Smith. *Elec. Times (Lond.)*, vol. 78, no. 2041, Dec. 4, 1930, pp. 975-979, 11 figs. Some consideration of their properties and their electrochemical action in general; actual characteristics and applications of copper oxid rectifiers in practice.

Radio

BROADCASTING. The Importance of Phase Control in Synchronizing, C. W. Horn. *Electronics*, vol. 1, no. 9, Dec. 1930, p. 423. Results of experiments carried out with cooperation of National Broadcasting Co., Radio Corporation of America, and American Telephone and Telegraph Co.; experimenting stations were maintained not only at same frequency but in fixed phase relation, several important and encouraging events transpired, no longer was program coming to local listeners disturbed, much area disappeared and those listeners in this area experienced increase in local field strength.

DETECTORS. Some Properties of Grid Leak Power Detection, F. E. Terman and N. R. Morgan. *Inst. Radio Engrs.—Proc.*, vol. 18, no. 12, Dec. 1930, pp. 2160-2175, 8 figs. It is shown theoretically that grid power detection can be obtained without undue distortion provided grid condenser reactance to modulation frequency, and grid leak resistance are related to degree of modulation in definite way; load limit of grid-leak power detector is point where plate rectification becomes appreciable, i. e., when straight line part of plate characteristic is exceeded; experimental results are given which verify theoretically determined point at which distortion becomes excessive.

Radio Frequency

STANDARDS. An International Comparison of Frequency by Means of a Luminous Quartz Resonator, S. Jimbo. *Inst. Radio Engrs.—Proc.*, vol. 18, no. 11, Nov. 1930, pp. 1930-1934, 1 fig. International comparison of frequency standards made with luminous quartz resonator shows different laboratories to be in agreement to one part in 100,000 when used to calibrate resonator at its flexual fundamental of about 10 kc.; observed agreement seems limited by luminous glow resonator used rather than by any difference between laboratory standards compared.

Relays

Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 720-726, and 728, 13 figs. Transmission line protective relays; nine major types of protective relays are used; after fundamental characteristics of these are fixed in mind, it is easy to remember combination of types used to give complete selective protection to particular arrangement of transmission lines; various types are discussed. (To be continued.)

Ship Propulsion

ELECTRIC. Wider Use of Electric Power for Propelling Ships, D. W. Niven. *Mar. Rev.*, vol. 60, no. 12, Dec. 1930, p. 43. Review of growing application of electric power to ship propulsion.

Telegraph Systems

Developments in Machine Telegraph Systems and Methods of Operation, H. H. Harrison. *Instn. Elec. Engrs.—Jl. (Lond.)*, vol. 68, no. 407, Nov. 1930, pp. 1369-1453 and (discussion) 1453-1468, 141 figs. Speed and phase control; definition of synchronism; motor speed control; governors; phase control; methods of generation of correction impulses; control of tuning-fork speed and phase by line signals; start-stop synchronism; local synchronism; general principles of synchronizing schemes; speed and phase indicators; phase adjustment or orientation; tuning forms; phonic-wheel motors; distributor construction and speed; rates of vibration of tuning of forks. Bibliography.

Telephone

CARRIER CURRENT. Function of Repeating Coils in Carrier Circuits, A. G. Ganz. *Bell Laboratories Rec.*, vol. 9, no. 3, Nov. 1930, pp. 134-136, 2 figs. Lack of metallic connection assists in keeping stray noise-producing voltages, picked up by line and transmitted longitudinally, from passing through terminal circuits; repeating coil also allows less-expensive unbalanced apparatus to be used without disturbing balance of line wires to ground.

TESTING. Comparative Transmission Tests, B. C. Burden. *Telephone Engr.*, vol. 34, no. 11, Nov. 1930, pp. 23-27, 6 figs. Notes on practical methods of testing efficiency of subsets, transmitters, and receivers; practical application of DB; transmission losses; transmission factors; loop losses; transmission loss due to eavesdropping on multi-party lines; transmission loss in central office equipment; transmission efficiency of subsets; transmission losses due to improper use of instruments; transmission losses in trunk plant; transmission testing circuits for determining instrument efficiency.

Telephone Relays

MAGNETIC INTERFERENCE. Effect of Magnetic Interference on Relay Operation, W. Buhler. *Bell Lab. Rec.*, vol. 9, no. 3, Nov. 1930, pp. 110-114, 5 figs. Part spreads out and returns to back end of core over longer path through air; any iron in vicinity due to its high permeability would become likely path for this stray flux to follow; because of this cores and armatures of nearby relays often serve to conduct stray flux; magnetic flux, which causes pull.

Television

Photoelectric Cells, Scanning Discs, Tiny Motors and Tube Current Meters, New Tools for Research, E. L. Manning. *Projection Eng.*, vol. 2, no. 11, Nov. 1930, pp. 20 and 24. Notes on equipment used in public television demonstration in Schenectady in which complete vaudeville program was transmitted 2 miles away from theater where it was presented.

Trackless Trolleys

DETROIT. Trolley Bus Operation Proves Advantageous at Detroit. *Elec. Ry. Jl.*, vol. 74, no. 13, Dec. 1930, pp. 753-754, 3 figs. Decreased operating costs, increased traffic, improved public relations, and almost entire freedom from accidents are advantages of trolley bus operation on Plymouth Road, Detroit.

GERMANY. Electric Trolley Bus Line Mettmann-Gruiten (Der lektrische Fahrdragtbus-Betrieb Mettmann-Gruiten), A. Schiffer. *Verkehrstechnik (Berlin)*, no. 38-39, Sept. 19, 1930, pp. 501-505, 5 figs. First modern electric trolley-bus line in Germany of Rheinisch-Westfaelische Elektrizitaetswerk, Essen; line of 5.77 km. total length is very much curved and only .86 per cent horizontal, rest is distributed over gradings from 1 to 10 and 1 to 30 inclinations; equipment described is run by 89 kw. 1425 r. p. m. at 750 to 800-volt d. c.; gear ratio 1:11.8.

Transmission and Distribution

Generation, Transmission and Distribution, H. R. Woodrow. *Power Plant Eng.*, vol. 34, no. 24, Dec. 15, 1930, pp. 1415-1418, 3 figs. Developments in electric systems process indicates improved network protection, development of vertical a.c. networks, better cable design and larger generators.

Vacuum Tubes

DETECTOR. The Estimation of the Sensitivity of the Grid Rectifier for Large Inputs, C. D. Hall. *Experimental Wireless (Lond.)*, vol. 7, no. 87, Dec. 1930, pp. 668-670, 5 figs. Measurements on sensitivity of grid rectifier using low impedance valves of "L" type with high anode voltages followed by resistance coupling; when practical results were compared with theoretical curve, former showed much smaller output than latter; as result of experiment, it was found to be due to small time constant or grid condenser and leak circuit.

Welding

ALLOY STEEL. Welding of Corrosion Resisting Steels, W. Spraragen. *Welding*, vol. 1, no. 14, Dec. 1930, pp. 979-980 and 985, 5 figs. General instructions covering welding technique used in arc welding, gas welding, resistance welding, and welding with shielded arc.

ARC. Significance of Welding of Depth in Arc Welding and Means for Improving (Die Bedeutung der Einbrandtiefe beim Lichtbogenschweissen und die Mittel zu ihrer Verbesserung), E. Schwartz. *V.D.I. Zeit. (Berlin)*, vol. 74, no. 46, Nov. 15, 1930, pp. 1565-1567, 18 figs. Factors controlling welding depth in d.c. arc welding; importance of welding depth for different types of joints and materials.

BOILERS. Welded Boiler, J. C. Hodge. *Mar. Eng. and Shipp. Age*, vol. 35, no. 12, Dec. 1930, pp. 652-658, 13 figs. Bureau of Engineering, U. S. Navy, has adopted arc-welded construction for joints of drums for 24 boilers now being built by Babcock & Wilcox Co., for new scout cruisers Minneapolis, New Orleans and Astoria; specifications drawn up are based on proposed specifications for fusion welding of drums or shells of power boilers published by A.S.M.E. boiler code committee; specifications governing test procedure.

BRONZE. Bronze Welding of Steel and Cast Iron, T. D. Ketchbaw. *Welding*, vol. 1, no. 14, Dec. 1930, pp. 981-985, 4 figs. General technique and property of bronze welds with particular reference to welding of locomotive frames and cylinders; tensile strength of bronze weld, properly made is around 50,000 lb. per sq. in.

BUILDINGS. Arc Welding on Steel Buildings, F. P. McKibben. *Civil Eng., (N. Y.)*, vol. 1, no. 3, Dec. 1930, pp. 205-206. Discussion by F. T. Llewellyn, H. M. Priest, J. L. Faden and S. H. Widdicombe of paper indexed from issue of Oct. 1930.

MACHINERY. Electric Welding and its Applications in the Manufacture of Electric Machinery (La soudure électrique et ses applications dans la construction des machines électriques), Taphanel and Weber. *Revue d'Electricité et de Mécanique (Paris)*, no. 13, Sept.-Oct. 1930, pp. 19-34, 34 figs. General notes on possibilities of electric welding; welding applied in electric manufacture plant construction illustrated by welded structures in France and of General Electric Plant in Philadelphia; applications of welding in machinery and equipment manufactured by Als. Thom. Co.

PIPE. Fusion Welding Specifications for Steel and Wrought Iron Pipe, J. H. Zink. *Welding*, vol. 1, no. 14, Dec. 1930, pp. 975-978, 7 figs. Specification adopted by Heating & Piping Contractors Assn. as to workmanship, design, and materials; single vee type joint; tables and sketches give data on beveling, spacing and tacking; fillet welds; welding neck flanges; tube turns; swages or reducers; dimensions and shapes of tee and angle joints.

PIPE LINES. Arc Welded Pipe Lines for Steam and Water Service, C. M. Taylor. *Plumbers and Heat. Contractors Trade Jl.*, vol. 89, no. 12, Dec. 15, 1930, pp. 17-18, 8 figs. Advantages of electric welding outlined with directions on how joints, reducers and plugs are to be made.

REPAIR SHOPS. Railroad Shops Save by Welding, J. C. Coyle. *West. Machy. World*, vol. 21, no. 11, Nov. 1930, pp. 489-491, 9 figs. Methods at Denver locomotive shops of Burlington railroad for repairing cylinder cracks, worn cross-heads, stoker screw, broken bolts, patching of fire-boxes, etc.; data on savings.

Welding Machines

Heavy Duty Butt Flash Welding Machines. *Engineer (Lond.)*, vol. 150, no. 3905, Nov. 14, 1930, p. 540. Extensive trials having shown that butt welding is satisfactory for certain purposes and that quality of weld may be equal to that of solid material, method is now widely adopted in railway works, shipyards, etc.; A.E.G. of Berlin, has designed machines in which clamping device is accessible on all sides and in which transformer is water cooled.

Development of Welding Equipment According to Langmuir Process in America and Germany (Die Entwicklung der Schweissgeraete nach dem Langmuir-Verfahren in Amerika und Deutschland), S. Sandelowsky. *Elektrotechnische Zeit. (Berlin)*, vol. 51, no. 58, Nov. 27, 1930, pp. 1649-1652, 11 figs. Electric equipment, transformers, etc., of arc atom welding process of General Electric Co. and development of same equipment at AEG; voltage protection.

Welds

TESTING. A Study of Welded Metals Under Fatigue Tests, G. E. Thorton. *Am. Welding Soc.—Jl.*, vol. 9, no. 10, Oct. 1930, pp. 48-66, 14 figs. Testing procedure and results obtained by Department of Mechanical Engineering of State College of Washington, in cooperation with American Bureau of Welding; sketch illustrates construction of Farmer type rotating beam testing machines; graphs and tables give data on properties of oxyacetylene weld, atomic hydrogen weld, metal arc weld; microphotograph illustrates crystal structure in weld and parent metal.

Tensile Tests for Welds, J. W. Owens. *Am. Welding Soc.—Jl.*, vol. 9, no. 10, Oct. 1930, pp. 79-88, 7 figs. Suggestions relating to standard A.S.T.M. tensile test specimens now used for fusion butt welds; sketches illustrate development of suitable shape of tension specimen to determine fusion and value of weld as joint; results of tests obtained with weld metal of high tensile strength and fair ductility.

Wiring

OFFICE BUILDINGS. Specifications for Electric Power Requirements in a Moderate Sized Office Building, J. C. Runyon. *Elec. Specifications*, vol. 2, no. 6, Dec. 1930, pp. 27-34. Sample specifications of moderate size office building of from 100,000 to 200,000 sq. ft. floor area. (To be continued.)

Electrical Installation in the Moderate Sized Office Building, F. Latzer. *Elec. Specifications*, vol. 2, no. 6, Dec. 1930, pp. 17-22 and 39, 7 figs. Lighting system layout of Park Building, Yonkers, N. Y. is described in detail; notes on metering; construction details; wiring devices; power system; service details; signal system.

Employment Notes

Of the Engineering Societies Employment Service

Positions Available

PHYSICIST OR ENGINEER to carry out research and testing on electric meters. Apply by letter only, stating age, race, nationality, education, technical experience and references. Location, Canada. W-2153.

MECHANICAL ENGINEER, Polish, with long experience in electric furnace castings. Must be conversant in tempering and forging works. Apply only by letter. Location, Europe. W-1920.

CHIEF OF ELECTRICAL INSTRUMENT ENGINEERING for manufacturer of electrical apparatus. It is essential that the applicant be able and willing to fit into an old and closely knit organization; that he be thoroughly familiar with the mathematical methods of instrument design, and that he have a knack and a liking for small mechanisms. While the financial return will be based on results and will eventually be adequate the attractiveness of this opening lies in the opportunity for real engineering achievement. Apply only by letter. Location, New York. W-2209.

Men Available

ELECTRICAL ENGINEER, 36, single, European education, North American training, good executive, nine languages. Eight years' experience, construction, maintenance; operation large public utility plants. Seven years' sales experience, various branches, expert in exports and government supplies, traveled over the world. Adaptable to any country, climate. Available now. Desires position abroad. C-8351.

GRADUATE ELECTRICAL ENGINEER, 1929, 22, single; 15 months on General Electric test course. Desires position with utility or manufacturing company or with concern doing consulting or construction engineering. Available immediately. Location, New England preferred. C-8028.

PUBLIC UTILITY ENGINEER, college graduate, class 1925. Married. Five years' general engineering experience on distribution and transmission work. Also wide construction experience, maintenance and operating supervision, appraisal, valuation, right-of-way, forecasting future load, commercial and power sales work, etc. Location, immaterial. C-4001.

GRADUATE ELECTRICAL ENGINEER, 26, single, 10 years' experience in motion picture projection; one year radio. Desires connection with concern interested in production end of motion pictures or television. Location, immaterial. Future behind position controlling factor. C-7934.

ELECTRICAL ENGINEER, 40, with mining, steel, and general industrial experience, available at once. Four years' in technical publishing, editorial capacity. Interested in research and development work, plants and processes, industrial investigations and financing plant operations, or general engineering. East preferred. B-4905.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, one and a half years with large electrical manufacturing concern in test and research departments; also familiar with repair work on distribution transformers and other apparatus. Available on short notice. Location preferred, New England or eastern part of country. C-8075.

ELECTRICAL ENGINEER, graduate, 33, married. Twelve years' experience, last six years in Latin America; for four years designed electrical machinery; five years public utilities, planning, design, supervision of construction of power plants and substations, three years chief electrical engineer raw sugar factory; fluent Spanish. Available February. Location preferred, New York City, vicinity. C-8553.

GRADUATE ELECTRICAL ENGINEER; 17 years' experience in electrical manufacturing; electric railway, power plant, substation and transmission line design and construction, desires connection with real opportunity. C-8256.

ELECTRICAL ENGINEER, university graduate, age 29, married. Seven years' varied experience in electrical design, purchasing and estimating for large power plant work. Also industrial, theater, apartment and office building experience with contracting engineers. Field and office. Desires position with engineering or contracting organization. Location preferred in the East. B-7454.

ELECTRICAL ENGINEER, 31, B. S.-E. E., 1926. One year as assistant electrical engineer making preliminary studies, investigations on hydroelectric projects; one year engineer, electrical control of armament on aeroplanes; two years car, material inspector, street railway company; one year student engineer large public utility; two years' electric car shop experience. C-6077.

INSTRUCTOR, graduate E. E. of a grade A European University and M. S. of a Southern University. Two years' teaching experience. Best references. Available June 1, 1931. Location, immaterial. C-8580.

COLLEGE GRADUATE, B. S. degree, Wesleyan University, 1924, in electricity, physics, mathematics. One year electrical test, meters. Six years electrician, power and light manager, estimating. Desires position as junior engineer in laboratory. Would consider position as chief electrician in manufacturing plant. Location, East. Available immediately. C-4294.

GRADUATE ELECTRICAL-MECHANICAL ENGINEER, 36, desires connection with public utility or industrial firm on power-station operation as engineer, or assistant to superintendent or engineer. Ten years' experience power-plant test, operation, design, construction, maintenance. Three years' electrical engineer for industrial concern. Two years assistant to power engineer. B-8379.

ASSISTANT EXECUTIVE, 39, married, technically trained. Connections with large public utility, manufacturers, and industrial consultants on work of administrative and commercial research nature. Especially qualified as assistant to busy executive needing man with management ability. Well endorsed. Prefer East. B-9122.

ARMATURE WINDER, 18 years' shop experience. Capable of handling all kinds of electrical motor repairs up to 250 kw. either a-c. or d-c., able to do all kinds of windings, old or new styles. Familiar with wiring for light and power. Desires position in shop or as electrician maintaining factory or office building. C-7952.

ELECTRICAL ENGINEER, graduate, 36, married. Twelve years' experience; last five years with very active consulting engineer. Design, writing specifications and requisitions, cost estimates, industrial surveys, supervision of electrical installations covering new and extensions to existing power houses and industrial plants. Valuable to consulting engineer or industrial concern. Available at once. C-343.

1929 GRADUATE ELECTRICAL ENGINEER, age 24, with year and half experience in manual and dial telephone work. Prefers work in radio or sound reproduction. Location in or near Maryland preferred. Available on short notice. C-8581.

ELECTRICAL ENGINEER, Bachelor's and Master's degrees; fourteen years peculiarly broad experience in test, research and development, standardization, consultation, university teaching, executive work, personnel; familiar with both power and radio equipment and practise. Stability and opportunity primary, initial salary and location secondary. Available at once. C-4951.

DEVELOPMENT ENGINEER, 29, with exceptional abilities for electrical relay circuits, as supervisory, remote or automatic control, automatic telephony, alarm systems, etc. Solves circuit problems with minimum of equipment (relays, contacts) and in record time. Also resourceful in small apparatus design. University graduate. At present employed. Desires connections with larger company. C-8373.

GRADUATE ELECTRICAL ENGINEER, 27, married. Seven years' test and laboratory experience with large electrical manufacturing company. Desires position as electrical engineer with manufacturing company or public utility. C-8592.

JUNIOR ENGINEER, 25, single. Desires connection with public utility, sound picture industry or radio manufacturing firm. General Electric test course, public utility distribution test experience. Test, design, construction, maintenance and engineering work in radio receiver manufacturing plant. Location, East. C-8596.

GRADUATE ELECTRICAL ENGINEER, age 29, married. Five years' maintenance and construction work. Three years's design, test and service work in distribution and power transformers. Also some sales experience. Interested in position with mining, public utility company or industrial concern. Reasonable salary with company offering opportunity. C-8539.

GRADUATE ENGINEER, 21, single, graduate in electrical engineering with B. S. degree. Twelve months' experience on electric meters. Desires position with opportunity for advancement with utility, manufacturing, or other engineering concern. Location preferred, New York or vicinity. C-8387.

ELECTRICAL ENGINEER, 30, married, B. S. in E. E. graduate student course, Westinghouse; substation construction from handling the tools to field engineer; cost keeping and material handling in construction department. Last two years substation and underground vault design. Additional education; business finance, Geneva College; Business management, La Salle; system stability, Westinghouse. C-8572.

ELECTRICAL ENGINEER, 24, married. Experience with oscillographs, vacuum tube amplifiers, and portable wireless sending and receiving set. Has done test work for utility. Also surveying experience. Holds second grade commercial wireless operators license. C-3035.

VALUATION ENGINEER, all phases of complete valuations; to take charge or do anything else, electrically trained. Accounting experience. C-234.

GRADUATE ELECTRICAL ENGINEER, 27, married. Six years' experience in substation and generating station design with middle western utility. Two years' graduate study in utility economics. Technical writing experience. Available on three weeks' notice. C-1331.

ELECTRICAL ENGINEER, B. S. degree, Iowa State College 1929, 26, married; now employed. Has had one year experience in physical testing laboratory of Western Electric Company. Desires position in the radio or electrical industries with opportunity for advancement. Location preferred, Middle West. Available on two weeks' notice. C-8632.

GRADUATE ELECTRICAL ENGINEER, 31, single. Previous to college education, 8 years' experience as a licensed electrician. Now teaching physics and mathematics in Springfield, Massachusetts. C-8633.

RESEARCH ENGINEER, exceptional theoretical and research grounding. Thoroughly familiar with commercial instruments. Two years' public utility engineering. Three and one-half years' responsible executive and development experience in highly specialized technical industry. Prefer small corporation in United States. Best references and connections. C-6938.

GRADUATE ELECTRICAL ENGINEER, experienced on testing, developmental manufacturing, electrical plant construction, wide experience all features design of power stations, indoor and outdoor substations, and industrial light and power. Checker two years. Squad leader two years. Will consider any location. B-9222.

ELECTRICAL ENGINEER, single, 30, Scandinavian, graduate Swiss Federal Institute of Technology, Zurich, with 6½ years' experience, four of them in United States, with manufacturing, mining, public utility and sugar companies, including operation, test, layout, estimate, inspection, drafting and design. Desires permanent position with future. Speaks German and Spanish. C-3764.

ELECTRICAL DESIGNER AND DRAFTSMAN, age 31, single. Eight years' public utility experience in steam and hydroelectric plants, substations and industrial plants. Graduate of technical school in mechanical and electrical engineering. Desires position with public utility or industrial company. C-4510.

RESEARCH ENGINEER, 27, Westinghouse graduate engineer, United States citizen, married, returning from two and one-half years of graduate study in Germany. Desires position for fundamental research in physics or in electrical engineering with an industrial organization; location preferred, Eastern United States. C-8642.

PYROMETER ENGINEER, 25 years of age, christian, single. Graduate of electrical engineering extension course of Columbia University. Have had five years' experience as a field engineer for a well known manufacturer of industrial instruments. Experienced in the construction, application and selling of pyrometers and automatic valves. C-8647.

GRADUATE ELECTRICAL ENGINEER, 1930. Seven months' experience in electrical substation layouts with a public utility. Desires related position in drafting or testing. Age 22. C-8293.

GRADUATE ELECTRICAL ENGINEER, 35, married. Twelve years' experience of which five as junior executive, with street railway, power and light utilities. Qualified for position as assistant general executive or in transmission

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
A. K. Krauser, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

or distribution department. Desires position with United States utility. Good references. Available immediately. C-5091.

DISTRIBUTION ENGINEER, 32, married. Six years' utility experience. Thoroughly familiar with organizing for economical maintenance, servicing, and construction, including records, accounting, reports. Some experience, steam power plant equipment, testing. Cornell University E. E. 1923. Now employed, junior executive on engineering and construction. Open for more responsible position, preferably in operating. C-5155.

ELECTRICAL ENGINEER, 37, married. Graduate from a German University. Fourteen years' experience in designing overhead and underground distribution lines, substations, and power and light distribution for industrial plants. Available at once. C-8648.

SOUND ENGINEER, 26, graduate E. E. One and one-half years recording engineer on talking motion pictures, 1½ years on audio amplifier design, remote control radio systems and public address systems. Thoroughly experienced on home recording apparatus. Available immediately. Location, New York and vicinity. C-4407.

CHINESE ELECTRICAL ENGINEER, Cornell graduate, M. M. E., G. E. test. Two years' public utility, nine years' power plant engineering experiences with leading American concerns, has great acquaintances among Chinese engineering circles, seeks connections with American manufacturers having interests in China. Location preferably, Shanghai, B-5548.

PROFESSOR OF ELECTRICAL ENGINEERING, 40, six years' successful experience teaching practically all branches electrical engineering, state school. Considerable experience power, telephone work. One year switchboard engineering department of Westinghouse. B. S. in E. E. and E. E. degrees. Prefer location, Rocky Mountain, Pacific Coast States. Available school year 1931-1932. C-5021.

ELECTRICAL, MECHANICAL ENGINEER, college graduate with wide practical experience in power plant work and industrial electrical equipment. Desires connection. Available immediately. B-2492.

ELECTRICAL-MECHANICAL ENGINEER employed by one of the leading consulting engineers for 13 years is now available. Experience covers design, construction and operation of high pressure steam turbine driven lectric generating stations and necessary high tension substations and transmission lines, and all phases of industrial engineering. C-8249.

ASSISTANT TO EXECUTIVE, electrical engineer, university graduate, 2 years' graduate work, 2 years' electrical instrument manufacturing and three years' public utility general testing experience. German fluent, reading knowledge of French, literary ability; engineering reports and correspondence. Pleasing personality, alert, industrious, reliable; excellent references. Wishes to relieve a busy executive. C-930.

ELECTRICAL ENGINEER, 1930 graduate, 25, single. Two years' drafting experience. Desires engineering work with opportunity for advancement. Location, immaterial. C-8437.

EXECUTIVE, production engineer, cost expert, cost accounts, budget control, practical, technical, commercial instruments, telephones, printing, machinery, pressed steel wave enamel, stainless steel, tunnel and galvanized. C-3241.

GRADUATE ELECTRICAL ENGINEER, 30. Two years' railroad shop and power plant experience, 4¼ years large eastern railroad electrical engineer's office drafting and design, appraisal electrical and power plant machinery, investigation and reports of engineering projects. Nineteen months electrician U. S. Shipping Board Diesel and Diesel-Electric motorships. Speak Spanish. C-8160.

ELECTRICAL ENGINEER, college graduate, A. I. T. Good character, married, 24. Pre-college experience: two years' middlewestern utilities as electrician's assistant; one year electrical repairs for self. Earned way through college and continuing now in repair business. Would like construction or central station installation work. Location anywhere. Available after June 15. C-8668.

ELECTRICAL ENGINEER, over 20 years' experience, design, construction and operation, power plants, distribution, substation and industrial installations of all kinds. Capable of taking charge either inside or outside or both and showing results. B-7034.

GRADUATE ELECTRICAL ENGINEER, with sound technical training who speaks Spanish readily and has wide technical experience including hydro-electric plant operation, distribution work and some steam experience. Desires responsible position with Latin American utility. B-4132.

ELECTRICAL ENGINEER, B. S., 1929, Westinghouse Student Course 1929-1930, with experience in meter engineering, desires place with public utility company in transmission, distribution or metering, or in development or research work. Will go anywhere. Would also consider engineering instruction job in technical school or college. C-8616.

GRADUATE ELECTRICAL ENGINEER, age 31, married. Eight years' experience including two years G. E. test, 1 year sales, 1 year valuation of lighting and telephone equipment and five years on electrical construction including estimating, layout work, and supervising installations. Desires a permanent connection with a future. B-9090.

ELECTRICAL ENGINEER, 35, technical education with 10 years' executive experience supervising both design and construction. Desires position as engineer in charge of design, or construction or as plant engineer. Location immaterial. C-8683.

SALES AND EXECUTIVE ENGINEER, electrically trained with experience in sales engineering, promotion and management. Would like to take an important part in progressive and high-grade organization. C-5431.

Membership

Transfers Recommended

The board of examiners, at its meetings of December 23, 1930, and January 20, 1931, recommended the following members for transfer to the grades of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BROOKS, HERBERT B., Physicist, Chief of Electrical Instrument Section, Bureau of Standards, Washington, D. C.

HARDING, ARTHUR L., Asst. Elec. Engr., Electric Bond & Share Co., New York.

KELMAN, J. N., President and Manager, Kelman Elec. & Mfg. Co., Los Angeles, Calif.

MOORE, ERNEST E., Consulting Foreign Engineer, Electric Bond & Share Co., New York, N. Y.

STONE, EDMUND O., System Development Mgr., Duquesne Light Co., Pittsburgh, Pa.

To Grade of Member

ALDERMAN, HAYWOOD L., Assistant Engineer, Electric Bond & Share Co., New York.

BABCOCK, ROBERT O., Asst. Engr., Brooklyn Edison Co., Brooklyn, N. Y.

BAILEY, ROBERT C., System Relay Engr., Virginia Elec. & Pr. Co., Richmond, Va.

BENNISON, LIONEL C., Hobart District Engr., Hydro Electric Commission, Hobart, Tasmania.

BRACKETT, HAROLD H., Engr. of Toll Plant Extension and Transmission, N. J. Bell Telephone Co., Newark, N. J.

BRESSLER, JOHN W., Electrical Engineer, Voorhees, Gmelin & Walker, New York

BROOKMEYER, EDGAR W., Vice-President and Secretary, The Brown Brockmeyer Co. Inc., Dayton, Ohio.

BRUNDIGE, JOHN A., Sponsor Engineer, Electric Bond & Share Co., New York.

CHESNUT, FRANK T., Elec. Engr., Ajax Electrothermic Corp., Trenton, N. J.

COOLEY, GILBERT, Asst. Engr., Electric Bond & Share Co., New York.

COONEY, RICHARD T., Supt. of Elec. Const., United Engineers & Constructors, Inc., Philadelphia, Pa.

CREASER, ISAIAH, Elec. Engr., The Replitura Corp., Stamford, Conn.

DAVIDSON, ROSS W., Sponsor Engineer, Electric Bond & Share Co., New York.

FAULKNER, ARTHUR S., Mains Engr., Electricity Dept., Brisbane City Council, Queensland, Australia.

FERGUSON, RANDON, Asst. Engr., Investigation of Stresses in Track, University of Illinois, Urbana, Ill.

FINN, JAMES J., Supt., The Roland T. Oakes Co., Holyoke, Mass.

FRIEND, OTTO A., Telephone Engr., American Tel. & Tel. Co., New York.

FROEHLICH, FREDERICK H., President, The Froehlich & Emery Engg. Co., Toledo, Ohio.

GARDNER, MURRAY F., Asst. Prof. of Elec. Engg., Mass. Inst. of Technology, Cambridge, Mass.

GOULD, LAWRENCE E., President, Economy Elec. Devices Co., Chicago, Ill.

HOISINGTON, N. P., Vice-President, W. V. Pangborne & Co., Inc., Philadelphia, Pa.

HOLDEN, EDWARD A., Asst. Engr., Electric Bond & Share Co., New York.

JICKLING, ROBERT W., Transmission and Distribution Engr., Saskatchewan Power Commission, Regina, Sask., Canada.

KATES, WILLARD A., Development Engr., Corning Glass Works, Corning, N. Y.

KEMP, PHILIP, Head of School of Engg., The Polytechnic, London, England.

LANGDON, GLEN G., Engg. Dept., American Gas & Electric Co., New York.

MACMURCHY, HERBERT G., Asst. Engr., Electric Bond & Share Co., New York.

MANGELS, WALTER C., System Operator, Public Service Elec. & Gas. Co., Newark, N. J.

MOORE, CHARLES R., Member, Technical Staff, Bell Telephone Laboratories, Inc., New York.

MOTTER, HARRY W., Sales and Consulting Elec. Engr., York, Pa.

NEUBER, MAX, Experimental and Development Engr., Moto Meter Gauge & Equipment Co., Toledo, Ohio.

NOTT, GORDON E., Transmission and Protection Engr., Southern California Telephone Co., Los Angeles, Calif.

OSBORN, CHARLES F., Elec. Engr., Ralston Purina Co., St. Louis, Mo.

PAOLINO, SERAFINO, Electrical Designing Draftsman, Pacific Gas & Elec. Co., San Francisco, Calif.

PENMAN, ROY F., Asst. Engr., Electric Bond & Share Co., New York.

PERRIN, LOUIS M., Asst. Elec. Engr., Bureau of Engg., City of San Francisco, San Francisco, Calif.

RICHARDSON, RICHARD P., Asst. Protection Engr., Electricity Dept., Sydney, N. S. W. Australia.

SATTERTHWAITE, J. P., Transmission Maintenance Methods Supervisor, American Tel. & Tel. Co., New York.

SEELEY, ARTHUR P., Elec. Engr., Westcott & Mapes, Inc., New Haven, Conn.

SHAW, ALFRED E., Elec. Engg., Virginia Elec. & Power Co., Richmond, Va.

SILLS, HUBERT R., Asst. Engr., Canadian General Electric Co., Peterboro, Ont., Canada.

SMITH, JOHN A., Elec. Engr., Arthur D. Riley & Co., Ltd., Wellington, N. Z.

STYFF, EIVIND, Elec. Engr., Aktieselskapet Norsk Elektrisk & Brown Boveri, Oslo, Norway.

VAUGHAN, GEORGE W., Asst. Engr., Electric Bond & Share Co., New York.

WHITAKER, WILLIAM G. H., Chief Engr., N. J. Bell Telephone Co., Newark, N. J.

◆

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before February 28, 1931.

Abas, J. A., Michigan College of Mining & Technology, Houghton, Mich.

Anderson, G. A., H. B. Squires Co., San Francisco, Calif.

Arapakis, G. H., (Member), New York Edison Co., New York, N. Y.

Arce, M. S., National Railways of Mexico, Chihuahua, Chih., Mexico

Arzadon, F. S., 27 West Superior St., Chicago, Ill.

Ashmead, H. E., American Tel. & Tel. Co., Cleveland, Ohio

Avary, S. A., General Electric Co., Schenectady, N. Y.

Avey, A. F., Niagara & Eastern Power Corp., Buffalo, N. Y.

Babb, M. A., General Electric Co., West Lynn, Mass.

Badgley, W. G., Jr., Public Service Elec. & Gas Co., Irvington, N. J.

Bagg, R. F., New York State, Watertown, N. Y.

Baker, A. E., Pennsylvania Railroad, New York, N. Y.

Baldwin, D. R., Aluminum Co. of America, Alcoa, Tenn.

Baltzar, J., Southern California Edison Co., Big Creek, Calif.

Barzilaski, P. M., N. Y. Navy Yard, Brooklyn, N. Y.

Bates, A. C., Purdue University, West Lafayette, Ind.

Beardsley, K. D., General Electric Co., Pittsfield, Mass.

Behm, J. H., General Electric Co., Schenectady, N. Y.

Bennett, G. R., Jr., 1559 Monterey Place, Mobile, Ala.

Berry, W. S., Underwriters' Laboratories, New York, N. Y.

Braum, C. M., City of Minneapolis, Minneapolis, Minn.

Brown, E. I., Cia. Hidroelectrica Guanajuantense, S. A., Mexico, D. F., Mex.

Bryant, F. R., Kent Owens Machine Co., Toledo, Ohio

Buehler, W. G., American Tel. & Tel. Co., Minneapolis, Minn.

Buel, K. F., Union Electric Light & Power Co., St. Louis, Mo.

Bukey, N. J., Union Gas & Electric Co., Cincinnati, Ohio

Bush, G. L., Teleregister Corp., New York, N. Y.

Cahoon, W. J., Houghton County Elec. Light Co., Houghton, Mich.

Caldwell, J., 3189 Grand Concourse, New York, N. Y.

Cameron, D. A., Public Service Co. of No. Illinois, Chicago, Ill.

Cameron, D. L., Skelly Oil Co., El Dorado, Kans.

Caparone, M. J., Rund Mfg. Co., Pittsburgh, Pa.

Carruth, H. B., Cupp Construction Co., Nashville, Ark.

Carter, B. H., Columbia Gas & Electric Co., Cincinnati, Ohio

Casper, C. L., American Tel. & Tel. Co., Nashville, Tenn.

Cedick, S. J., Cleveland Railway Co., Cleveland, Ohio

Clarendon, C. H., Jr., Weston Electrical Instrument Corp., Newark, N. J.

Clark, G. J., General Electric Co., Toledo, Ohio

Clark, M. C., Pennsylvania Railroad, Long Island City, N. Y.

Clark, W. R., Leeds & Northrup, Philadelphia, Pa.

Clarkson, W. G., Canadian Westinghouse Co., Hamilton, Ont., Can.

Coan, M., A. S. Riggs, New York, N. Y.

Colson, H. L., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
(Applicant for re-election)

Coyle, W. A., Jr., 573 Hopkins St., Buffalo, N. Y.

Critchett, C. A., Ohio Bell Tel. Co., Dayton, Ohio

Crittendon, L. R., DuPont Ammonia Corp., Belle, W. Va.

Crosno, C. D., Iowa State College, Ames, Ia.

Cummings, H. B., Jr., Georgia Power Co., Atlanta, Ga.

Dapson, F. L., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.

Davis, K. C., General Electric Co., Toledo, Ohio

Demeros, A. G., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Dixon, I. H., Consolidated Gas Elec. Lt. & Pr. Co., Baltimore, Md.

Dorr, G., Toledo Edison Co., Toledo, Ohio

Doss, L. F., New Jersey Bell Tel. Co., Newark, N. J.

Duncan, D. C., Illinois Bell Telephone Co., Chicago, Ill.

Eastman, C. A., Pennsylvania Power & Light Co., Allentown, Pa.

Eckert, O. E., (Member), Board of Water & Electric Light Commissioners, Lansing, Mich.

Elg, G. W., New York Edison Co., New York, N. Y.

Estler, K. E., Westinghouse Lighting Institute, New York, N. Y.

Evans, O. D., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Ewart, J. N., Buffalo General Electric Co., Buffalo, N. Y.

Falconer, M. C., City of Tacoma, Hoodsport, Wash

Farrelly, J. W., Southwestern Bell Tel. Co., San Antonio, Tex.

Ferrick, J. H., American Tel. & Tel. Co., Pittsburgh, Pa.

Fishburne, C. L., Jr., University of South Carolina, Columbia, S. C.

Fisher, C. E., Bell Tel. Labs., New York, N. Y.

Flarida, H. R., Robbins & Myers, Springfield, Ohio

Flippin, A. W., Pacific Gas & Electric Co., Oakland, Calif.

Foley, J. A., General Electric Co., Toledo, Ohio

Forfa, J. S., United Elec. Service Co., New York, N. Y.

Foster, H. K., Dalton-Marsh Co., Danvers, Mass.

Franks, S. T., Canadian & General Finance Co., Ltd., Toronto, Ont., Can.

Freeland, F., Northwestern Electric Co., Portland, Ore.

Fuller, H. M., Philips Wire Co., Darlington, R. I.

Garrett, R. F., Western Electric Co., Kearny, N. J.

Geer, G. D., Texas Electric Service Co., Sweetwater, Tex.

Giddens, A. J., Cleveland Railway Co., Cleveland, Ohio

Gille, W. H., Minneaplis Honeywell Reg. Co., Minneapolis, Minn.

Gillis, J. D., University of Santa Clara, Santa Clara, Calif.

Glendinning, W., Brooklyn Edison Co., Brooklyn, N. Y.

Greenman, H. F., New England Public Service Co., Augusta, Me.

Greer, D. M., Westinghouse Elec. & Mfg. Co., Newark, N. J.

Guenthner, R. H., Northwestern Public Service Co., Yankton, S. D.

Gwathmey, L., General Electric Co., Schenectady, N. Y.

Hague, C. W., General Electric Co., Cleveland, Ohio

Haldeman, W. F., Motor Products Corp., Detroit, Mich.

Hallar, E., United Electric Light Co., Springfield, Mass.

Hamilton, J. A., Bell Tel. Co. of Pa., Pittsburgh, Pa.

Hammer, K. E., Bell Telephone Laboratories, New York, N. Y.

Hansen, P. B., (Member), Graybar Electric Co., Inc., Minneapolis, Minn.

Harrington, J. R., (Member), Howe Signal Co.; Howe Mfg. Co., Chicago, Ill.

Hartig, O., Eagle Electric Mfg. Co., Brooklyn, N. Y.

Haspel, G. K., (Member), Independent Sales & Engineering Co. Ltd., Vancouver, B. C., Can.

Hazelton, R. M., 470 E. 161st St., New York, N. Y.

Heine, T. C., New York Tel. Co., New York, N. Y.

Hellwarth, A. R., University of Michigan, Ann Arbor, Mich.

Helwig, W. F., (Member), Texas Technological College, Lubbock, Tex.

Hendricks, W., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.

Henrikson, F. W., General Electric Co., New York, N. Y.

Hentzen, H. K., Southwestern Bell Tel. Co., Kansas City, Mo.

Hindman, B. W., Public Service Co. of No. Ill., Maywood, Ill.

Hollingshead, E. C., Westinghouse Elec. & Mfg. Co., Sharon, Pa.

Horsfall, J. D., Ohio Bell Tel. Co., Cleveland, Ohio

Horvath, J. J., Electric Bond & Share Co., New York, N. Y.

Hoshiai, M., c/o Consulate General of Japan, New York, N. Y.

Hrubec, T. T., General Cable Corp., Perth Amboy, N. J.

Hultberg, C. A., Transformer Corp. of America, Chicago, Ill.

Huskin, F. P., Carolina Power & Light Co., Asheville, N. C.

Hynes, F. B., (Fellow), Crocker Wheeler Elec. Mfg. Co., Amper, N. J.

Irvine, G. L., General Electric Co., Schenectady, N. Y.

Ivanoff, N. A., D. L. & W. Railroad Co., Hoboken, N. J.

Jacob, F. N., RCA Victor Co., Inc., Mt. Lebanon, Pa.

Janone, V., General Cable Corp., Rome, N. Y.

Jasper, H. N., Jr., American Tel. & Tel. Co., Cleveland, Ohio

Jenkins, S. P., Utah Copper Co., Bingham Canyon, Utah

Jeremiah, W. S., Pennsylvania Power & Light Co., Hazleton, Pa.

Jivatode, R. S., Carolina Pr. & Lt. Co., Raleigh, No. Car.

Jones, H. H., Brooklyn Edison Co., Brooklyn, N. Y.

Jones, T. B., Ohio Brass Co., Dallas, Tex.

Joy, C. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Judd, R. S., Southern New England Tel. Co., New Haven, Conn.

Judkins, A., 37 Rolfe St., Auburn, R. I.

Keachie, J. H., General Electric Co., Schenectady, N. Y.

Kemper, G. W., Westinghouse Elec. & Mfg. Co., Sharon, Pa.

Kennard, W., 210 Pierce Hall, Cambridge, Mass.

Kerigan, F. A., Pennsylvania Railroad Co., Altoona, Pa.

Kerley, V. E., Oregon State College, Corvallis, Ore.

Killingsworth, H. M., General Electric Co., Philadelphia, Pa.

Kimball, G. S., Stanford University, Stanford University, Calif.

King, W. L., Northwestern Bell Tel. Co., Rapid City, So. Dak.

Kinney, A. B., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Kissner, E., Little & Branch, New York, N. Y.

Klein, H., 687 Lexington Ave., New York, N. Y.

Knapp, E. W., Shawinigan Water & Power Co., Montreal, Que., Can.

Knapp, N., Jr., Bell Tel. Labs., Inc., New York, N. Y.

Knerr, L. R., Pacific Gas & Electric Co., Oakland, Calif.

Kohli, W. W., Standard Sanitary Mfg. Co., Tiffin, Ohio

Korba, A. A., Northern States Power Co., St. Paul, Minn.

Kramer, A., Puget Sound Pr. & Lt. Co., Seattle, Wash.

Lafranchi, V., City Light Dept. of Seattle, Seattle, Wash.

Langford, J. W., Jr., General Electric Co., Philadelphia, Pa.

Larson, H. O., Western Electric Co., Kearny, N. J.

Leary, J. F., Trinidad Leaseholds, Ltd., Trinidad, B. W. I.

Leary, J. R., Bell Tel. Co. of Pa., Pittsburgh, Pa.

Ledermann, W., Sargent & Lundy, Chicago, Ill.

Leithead, R. C., Mass. Inst. of Technology, Cambridge, Mass.

Lewis, F. A., "Electrical Engineering," 33 W. 39th St., New York, N. Y.

Lindell, C. H., Union Gas & Electric Co., Cincinnati, Ohio

Linn, G. J., Commonwealth Edison Co., Chicago, Ill.

Linton, E. W., New York Tel. Co., Brooklyn, N. Y.

Louttit, W. C., (Member), United Railways of Havana, Havana, Cuba

Lucas, E. L., 3959-15th Ave., N. E., Seattle, Wash.

Lucas, F. L., City of Toledo, Toledo, Ohio

Ludlam, G., Western Electric Co., Pittsburgh, Pa.

Mabson, E. B., Louisiana Power & Light Co., Algiers, La.

Mahan, K. C., General Electric Co., Schenectady, N. Y.

Marine, E. H., Bureau of Power & Light of Los Angeles, Saugus, Calif.

Martin, H. L., Westinghouse Elec. & Mfg. Co., Chicago, Ill.

Marx, W. F., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.

Mathewson, H. G., Southwestern Bell Tel. Co., Dallas, Tex.

Matson, J. W., Jr., Union Switch & Signal Co., Swissvale, Pa.

Matthes, L. H., General Electric Co., Beaumont, Tex.

Mattos, G. E., 563 North Sixteenth St., San Jose, Calif.

McCown, R. L., Texas Electric Service Co., Fort Worth, Tex.

McCurley, J. B., Chesapeake & Potomac Tel. Co. of Balto., Baltimore, Md.

McFadden, J. J., Pennsylvania Power & Light Co., Hazleton, Pa.

McHugh, J. H., City of St. Paul, St. Paul, Minn.

McVeety, S. R., Can. General Electric Co., Toronto, Ont., Can.

Metzger, A. F., General Electric Co., Schenectady, N. Y.

Mexal, J. R., Sarvas Electric Co., Inc., New York, N. Y.

Mickle, H. I., Ford Instrument Co., Long Island City, N. Y.

Miller, M. R., 1018 Promontory Ave., Oregon City, Ore.

Molloy, J. A., Brooklyn Edison Co., Brooklyn, N. Y.

Monnier, C. F., New York Power & Light Corp., Albany, N. Y.

Mooshian, J. L., United Electric Lt. & Pr. Co., New York, N. Y.

Morris, H. D., Stone & Webster Engg. Corp., Boston, Mass.

Morrison, C., Potomac Edison Co., Hagerstown, Md.

Morse, M. F., New York Tel. Co., Brooklyn, N. Y.

Mucher, G. J., Clarostat Mfg. Co., Inc., Brooklyn, N. Y.

Newhouse, S. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Nicholson, G. J., New York & Queens Elec. Lt. Co., Flushing, N. Y.

Oberbauer, C. T., Edgar, Mont.

O'Callaghan, J. J., Stewart Wagner Corp., Chicago, Ill.

Odbert, E. W., Jr., Sturgeon Bay Co., Sturgeon Bay, Wis.

Oehlwein, O. L., Public Service Co. of No. Ill., Evanston, Ill.

Oliver, R. A., New York Central Railroad, New York, N. Y.

Olsen, O. F., General Electric Co., Schenectady, N. Y.

Oppenheimer, M. L., North American Electric Lamp Co., St. Louis, Mo.

Orrick, E. F., General Electric Co., Schenectady, N. Y.

Osborne, R. H., Public Service Co. of No. Illinois, Joliet, Ill.

Osgood, R. H., Hazard Insulated Wire Works, New York, N. Y.

Ott, W. M., New York Tel. Co., Syracuse, N. Y.

Pabalan, R. L., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

Paulaharju, L. J., Can. Westinghouse Co. Ltd., Hamilton, Ont., Can.

Paulding, H. L., Dow Jones & Co., New York, N. Y.

Peach, P. S., 315 N. Highland Ave., Pittsburgh, Pa.

Pennock, E. C., Westinghouse Elec. & Mfg. Co., Denver, Colo.

Peugnet, C. R., Rensselaer Polytechnic Institute, Troy, N. Y.

Pfester, P., Cleveland Railway Co., Cleveland, Ohio

Plant, I. M., Brooklyn Edison Co., Brooklyn, N. Y.

Poohan, S. L., R. C. A. Photophone, Inc., New York, N. Y.

Poole, G. D., Western Union Telegraph Co., Chicago, Ill.

Potter, D. F., Jr., (Member), Kuhlman Electric Co., New York, N. Y.

Pritham, C. F., N. Y. N. H. & H. R. R. Co., New Haven, Conn.

Pyne, A. N., Union Carbide Co. & Electro Metallurgical Co., Niagara Falls, N. Y.

Quell, C. H., General Talking Pictures Corp., New York, N. Y.

Quirk, M. J., Ford Motor Co., Dearborn, Mich.

Rehm, W. P., U. S. Lines, Inc., New York, N. Y.

Remon, J. A., (Member), Chesapeake & Potomac Tel. Co., Richmond, Va.

Reynolds, R. I., Syracuse Lighting Co., Inc., Syracuse, N. Y.

Ring, D. H., Bell Telephone Laboratories, Red Bank, N. J.

Rollman, W. H., Memphis Power & Light Co., Memphis, Tenn.

Rothstein, A. I., Kansas City Pr. & Lt. Co., Kansas City, Mo.

Rowe, H. N., General Electric Co., Schenectady, N. Y.

Roy, J. A., Bureau of Ordnance, Navy Dept., Washington, D. C.

Roy, K. C., Mass. Inst. of Technology, Cambridge, Mass.

Rudder, A. L., Hydro Electric Power Comm. of Ontario, Toronto, Ont., Can.

Rudiger, O. E., Cornell University, Ithaca, N. Y.

Rys, F. E., Westinghouse Elec. & Mfg. Co., Bondsville, Mass.

Sanderson, B. E., Public Service Co. of No. Illinois, Chicago, Ill.

Sandstrom, A. T., Anaconda Copper Mining Co., Butte, Mont.

Sandstrom, F. G., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.

Schaub, W. R., Bureau of Standards, Washington, D. C.

Schlesinger, O. J., (Member), A. A. Electric Co., Cicero, Ill.

Schlottmann, F. W., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

Schmidt, E. C., Southwestern Bell Tel. Co., St. Louis, Mo.

Schmitt, W. H., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

Schoemann, A. F., General Electric Co., Philadelphia, Pa.

Schultz, C. H., John C. Morris, Inc., Jersey City, N. J.

Schwab, D., Engert-Hellman, Inc., New York, N. Y.

Schwarzkopf, E., 3733-80th St., Jackson Heights, L. I., N. Y.

Sharp, W. B., Southern Bell Tel. Co., Jackson, Miss.

Shoemaker, L. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.

Schoenfeld, K., E. A. Everett, Long Island City, N. Y.

Siekman, P. W., Pennsylvania Power & Light Co., Hazleton, Pa.
Sigman, H. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Sissung, E. P., M. H. Schmoyer, Allentown, Pa.
Skinner, C. R., Correct Recording System Mfg. Co., Palo Alto, Calif.
Smeed, R. W., 1740 East 116th Place, Cleveland, Ohio
Smith, G. A., Bell Tel. Laboratories, New York, N. Y.
Snyder, E. R., Sargent & Lundy, Chicago, Ill.
Stanfield, D. R., So. Calif. Tel. Co., Los Angeles, Calif.
Stelpstra, E. J., Western Electric Co., Inc., Newark, N. J.
Strasbourger, J. C., Cleveland Electric Illuminating Co., Cleveland, Ohio
Strazzella, A. F., Bethlehem Steel Co., Milroy, Pa.
Stringham, R. P., University of Kansas, Lawrence, Kans.
Strohl, W. M., Bell Tel. Labs., Red Bank, N. J.
Strong, C. H., National Inspection Co., Chicago, Ill.
Stuttle, A. F., Ohio Bell Tel. Co., Toledo, Ohio
Swingle, A. W., General Electric Co., Schenectady, N. Y.
Tarvin, E. R., American Tel. & Tel. Co., New York, N. Y.
Taylor, C. F., Western Electric Co., Seattle, Wash.
Thomas, J. E., Brooklyn Edison Co., Brooklyn, N. Y.
Thomas, M. I., 8747 Laflin St., Chicago, Ill.
Thomas, R. E., (Member), Bell Tel. Co. of Pa., Wilkes-Barre, Pa.
Thomson, W. A., Northern Electric Co., Montreal, Que., Can.
Tietzow, O. E., Sargent & Lundy, Inc., Chicago, Ill.
Toepfer, A. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Turner, W. O., Louisiana Power & Light Co., Algiers, La.
Turpin, A. F., Public Service Co. of No. Ill., Waukegan, Ill.
Tycks, C. P., Staten Island Edison Corp., Livingston, S. I., N. Y.
Ullman, R., Brown Instrument Co., Philadelphia, Pa.
Vatcher, G. I., Urquehart-Hardy Radio Labs., Dorchester, Mass.
Vest, W. L., Jr., Western Massachusetts Companies, Springfield, Mass.
Victors, P., Shell Chemical Co., Pittsburg, Calif.
Volkmann, H., 3523 North 18th St., Milwaukee, Wis.
Walker, C. M., Champion Radio Works, Inc., Danvers, Mass.
Walsh, T. N., Geophysical Service, Inc., Dallas, Tex.
Walters, H. B., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Webber, T. T., New York Fire Dept., Woodhaven, N. Y.
Weber, E., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Weber, F. D., Western Electric Co., Chicago, Ill.
Weil, R. G., Bell Tel. Labs., New York, N. Y.
Welch, H., Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Wendegatz, L. G., Line Material Co., Kansas City, Mo.
West, W. B., (Member), 22 East 38th St., New York, N. Y.
Williams, G. M., Public Service Co. of No. Ill., Crystal Lake, Ill.
Wirth, S., Brooklyn Edison Co., Brooklyn, N. Y.
Witt, M., Georgia Power Co., Atlanta, Ga.
Woodward, H., Annapolis & Chesapeake Power Co., Annapolis, Md.
Wylie, D. N., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Total 281

Foreign

de la Serna, R. T., Cia. Interprovincial de Servicios Publicos Buenos Aires, Argentina, So America
Del Ray, J., Electric Supply Co., Cuttack, India
Hayath, M., Government of Mysore, Bangalore, India
Iyengar, K. I., Government of India, Bombay, India
Knight, S. A., Irak Petroleum Co., Ltd., Tuz Khurmatu, Irak
Pratt, A. A., Riegos y Fuerza del Ebro, S. A., Provincia de Lenida, Spain
Smith, J. A., Australian General Electric Co., Ltd., Adelaide, South Australia
Snyder, I. W., Standard Oil Co., Yokohama, Japan
Sugaya, Y., Nagoya Communications, Higashi-Ku, Nagoya-Shi, Japan
Utley, C. L., Emprezas Electricas, Rio de Janeiro, Brazil, So. America
Watts, E. A., Municipal Council of Sydney, New South Wales, Australia
White, C. E., (Member), Century Electric Co. of St. Louis, Mo., London, Eng.
Total 12

Officers and Committees

Institute Officers 1930-1931

President

WILLIAM S. LEE

Junior Past Presidents

R. F. SCHUCHARDT
HAROLD B. SMITH

Vice-Presidents

HERBERT S. EVANS
W. S. RODMAN
C. E. FLEAGER
E. C. STONE
C. E SISSON
H. V. CARPENTER
G. C. SHAAD
I. E. MOULTROP
H. P. CHARLESWORTH
T. N. LACY

Directors

F. C. HANKER
E. B. MEYER
H. P. LIVERSIDGE
J. ALLEN JOHNSON
A. M. MacCUTCHEON
A. E. BETTIS
J. E. KEARNS
F. W. PEEK, Jr.
C. E. STEPHENS
A. B. COOPER
A. E. KNOWLTON
R. H. TAPSCOTT

National Treasurer

W. I. SLICHTER

National Secretary

F. L. HUTCHINSON

General Counsel

PARKER & AARON
30 Broad Street, New York

Local Honorary Secretaries

T. J. Fleming, Calle B. Mitre 519, Buenos Aires, Argentina, S. A.
H. W. Flashman, Aus. Westinghouse Elec. Co., Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.
F. M. Servos, Rio de Janiero Tramways, Light & Power Co., Rio de Janeiro, Brazil.
A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.
A. S. Garfield, 173 Boulevard Haussmann, Paris 8 E., France.
Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. A. Chatelain, Polytechnical Institute, Apt. 27, Leningrad, Sosnowka 1/3, U. S. S. R.
Axel F. Enstrom, 24a Ingeniorsvetenskrapsakademien, Stockholm, 5 Sweden.
W. Eldson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

INSTITUTE COMMITTEES

(A list of the personnel of Institute committees may be found in the January issue of ELECTRICAL ENGINEERING)

General Standing Committees and Chairmen

Executive	W. S. Lee
Finance	C. E. Stephens
Meetings and Papers	A. E. Knowlton
Publication	W. S. Gorsuch
Coordination of Institute Activities	H. P. Charlesworth
Board of Examiners	H. W. Drake
Sections	Everett S. Lee
Student Branches	W. H. Timbie
Membership	J. Allen Johnson
Headquarters	R. H. Tapscott
Law	E. B. Meyer
Public Policy	Bancroft Gherardi
Standards	F. D. Newbury
Edison Medal	D. C. Jackson
Lamme Medal	Charles F. Scott
Code of Principles of Professional Conduct	F. B. Jewett
Award of Institute Prizes	A. E. Knowlton
Safety Codes	A. W. Berresford
Engineering Profession	H. A. Kidder
Columbia University Scholarships	W. I. Slichter
Popular Science Award	A. E. Knowlton
Advisory Committee to the Museum of Science and Industry in the City of New York	J. P. Jackson

Technical Committees and Chairmen

Automatic Stations	F. Zogbaum
Communication	G. A. Kositzky
Education	W. R. Work
Electrical Machinery	Philip L. Alger
Electric Welding	P. P. Alexander
Electrochemistry and Electrometallurgy	P. H. Brace
Electrophysics	O. E. Buckley
General Power Applications	C. W. Drake
Instruments and Measurements	E. J. Rutan
Applications to Iron and Steel Production	A. C. Cummins

Production and Application of Light	George S. Merrill
Applications to Marine Work	R. A. Beekman
Applications to Mining Work	Carl Lee
Power Generation	F. A. Allner
Power Transmission and Distribution	P. H. Chase
Protective Devices	Raymond Bailey
Research	L. W. Chubb
Transportation	Sidney Withington

INSTITUTE REPRESENTATIVES

(The Institute is represented on the following bodies; the names of the representatives may be found in the January issue of ELECTRICAL ENGINEERING)

Aeronautical Radio Research, Liaison Committee on
Alfred Noble Prize Committee, A. S. C. E.
American Association for the Advancement of Science, Council
American Bureau of Welding
American Committee on Electrolysis
American Engineering Council Assembly
American Marine Standards Committee
American Standards Association
American Year Book, Advisory Board
Charles A. Coffin Fellowship and Research Fund Committee
Committee of Apparatus Makers and Users, National Research Council
Committee on Elimination of Fatigue, Society of Industrial Engineers
Committee on Heat Transmission, National Research Council
The Engineering Foundation
Engineering Societies Monographs Committee
Hoover Medal Committee
John Fritz Medal Board of Award
Joint Committee on Welded Rail Joints
Joint Conference Committee of Four Founder Societies
Library Board, United Engineering Trustees, Inc.
National Fire Protection Association, Electrical Committee
National Fire Waste Council
National Research Council, Engineering Division
National Safety Council, Electrical Committee of A. S. S. E.—Engineering Section
Radio Advisory Committee, Bureau of Standards
United Engineering Trustees, Inc.
U. S. National Committee of the International Commission on Illumination
U. S. National Committee of the International Electrotechnical Commission
Washington Award, Commission of

GEOGRAPHICAL DISTRICT EXECUTIVE COMMITTEES

District	Chairman (Vice-President, A. I. E. E.)	Secretary (District Secretary)
No. 1—North Eastern	I. E. Moultrop, Edison Elec. Illum. Co., 39 Boylston St., Boston	A. C. Stevens, General Electric Co., Schenectady
No. 2—Middle Eastern	E. C. Stone, Duquesne Light Co., 435 Sixth Ave., Pittsburgh	J. A. Cadwallader, Bell Tel. Co. of Pa., 416 Seventh Ave, Pittsburgh
No. 3—New York City	H. P. Charlesworth, 463 West St., New York	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York
No. 4—Southern	W. S. Rodman, Box 675, University, Va.	J. S. Miller, Jr., Box 12, University, Va.
No. 5—Great Lakes	T. N. Lacy, Mich. Bell Tel. Co., 1365 Cass Ave., Detroit	A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis
No. 6—North Central	Herbert S. Evans, University of Colorado, Boulder, Colo.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. C. Shaad, University of Kansas, Lawrence, Kans.	Robert W. Warner, University of Kansas, Lawrence, Kans.
No. 8—Pacific	C. E. Fleager, Pac. Tel. & Tel. Co., 140 New Montgomery St., San Francisco	H. W. Hitchcock, 1050 Telephone Bldg., 740 South Olive St., Los Angeles
No. 9—North West	H. V. Carpenter, State College of Washington, Pullman, Wash.	R. D. Sloan, State College of Washington, Pullman, Wash.
No. 10—Canada	C. E. Sisson, Canadian Gen. Elec. Co., 1025 Lansdowne Ave., Toronto, Ont.	W. L. Amos, Hydro-Elec. Pr. Com., 190 University Ave., Toronto, Ont.

Note: Each District Executive Committee includes the chairmen and secretaries of all Sections within the District and the chairman of the District Committee on Student Activities.

LOCAL SECTIONS OF THE INSTITUTE

Name	District	Chairman	Secretary	Secretary's Address
Akron	2	H. C. Paiste	Alvin P. Regal	Phila. Rubber Works Co., Akron, Ohio
Atlanta	4	H. C. Uhl	O. O. Rae	Westinghouse E. & M. Co., Atlanta, Ga.
Baltimore	2	W. B. Kouwenhoven	J. Wells	Western Elec. Co., 25 Broening Rd., Baltimore, Md.
Birmingham	4		O. E. Charlton	Allied Engineers, Inc., Birmingham, Ala.
Boston	1	J. P. Kobrock	G. J. Crowdes	Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
Chicago	5	F. H. Lane	L. R. Mapes	Ill. Bell Tel. Co., 212 W. Washington St., Chicago, Ill.
Cincinnati	2	T. C. Reed	L. L. Bosch	Columbia Eng. & Mgt. Corp., 314 West 4th St., Cincinnati, Ohio
Cleveland	2	F. W. Braund	John M. Smith	Nela Park, Cleveland, Ohio
Columbus	2	C. D. Price	K. Y. Tang	Ohio State University, Columbus, Ohio
Connecticut	1	Samuel Ferguson	R. G. Warner	Yale Univ., 10 Hillhouse Ave., New Haven, Conn.
Dallas	7	L. T. Blaisdell	G. A. Dyer	Southwestern Bell Tel. Co., Dallas, Texas
Denver	6	R. B. Bonney	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	LeRoy Braisted	J. J. Shoemaker	Detroit Edison Co., 2000-2nd Ave., Detroit, Mich.
Erie	2	G. R. McDonald	G. I. LeBaron	General Elec. Co., Erie, Pa.
Fort Wayne	5	W. J. Morrill	C. M. Summers	General Elec. Co., Fort Wayne, Ind.
Houston	7	C. D. Farman	Hezzie Clark	Humble Pipe Line Co., Drawer, 1761, Houston, Texas
Indianapolis-Laf	5	E. G. Ralston	C. E. Dutton	15 W. New York St., Room 222, Indianapolis, Ind.
Iowa	5	J. K. McNeely	H. B. Hoffhaus	Des Moines El. Lt. Co., 312-6th Ave., Des Moines, Iowa
Ithaca	1	W. C. Ballard, Jr.	W. E. Meserve	614 E. Buffalo St., Ithaca, N. Y.

LOCAL SECTIONS OF THE INSTITUTE—*Continued*

Name	District	Chairman	Secretary	Secretary's Address
Kansas City	7	J. S. Palmer	Richard M. Ryan	510 Dwight Bldg., Kansas City, Mo.
Lehigh Valley	2	W. M. Harbaugh	J. H. Diefenderfer	Penn. Pr. & Lt. Co., Hazleton, Pa.
Los Angeles	8	H. W. Hitchcock	Philip S. Biegler	3551 University Ave., Los Angeles, Calif.
Louisville	4	James Clark, Jr	Philip P. Ash	L. & N. R. R. Bldg., 9th and Broadway Ave., Louisville, Ky.
Lynn	1	A. L. Ellis	W. K. Dickinson	General Elec. Co., West Lynn Works, Lynn, Mass.
Madison	5	L. C. Larson	G. F. Tracy	Elec. Lab. Bldg., Univ. of Wisconsin, Madison, Wis.
Memphis	4	M. Eldredge	W. A. Gentry	Memphis Pr. & Lt. Co., Memphis, Tenn.
Mexico	3	B. E. Arias	L. Castro, Jr	Departamento Electricidad y Telegrafos, Ferrocarriles Nacionales de Mexico, Mexico, D. F.
Milwaukee	5	F. A. Kartak	I. L. Illing	Milwaukee El. Ry. & Lt. Co., 380 Pub. Serv. Bldg., Milwaukee, Wis.
Minnesota	5	D. K. Lewis	H. J. Pierce	Northwestern Bell Tel. Co., Minneapolis, Minn.
Nebraska	6	W. O. Jacobi	A. L. Turner	1112 Telephone Bldg., Omaha, Nebraska
New York	3	J. B. Bassett	C. R Jones	Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
Niagara Frontier	1	E. S. Bundy	G. W. Eighmy	General Elec. Co., 1100 Elec. Bldg., Buffalo, N. Y.
North Carolina	4	J. H. Paget	F. C. DeWeese	Carolina Pr. & Lt. Co., Raleigh, N. C.
Oklahoma City	7	F. J. Meyer	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	D. H. Kelly	J. L. MacBurney	El. St. Bat. Co., 1955 Hunting Park Ave., Phila., Pa.
Pittsburgh	2	C. T. Sinclair	F. A. Connor	General Elec. Co., 1309 Oliver Bldg., Pittsburgh, Pa.
Pittsfield	1	C. H. Kline	L. H. Burnham	General Electric Co., Pittsfield, Mass.
Portland, Ore	9	A. H. Kreul	C. W. Fick	General Electric Co., Portland, Oregon
Providence	1	J. W. Young	O. W. Briden	Blackstone Valley G. & E. Co., 231 Main St., Pawtucket, R. I.
Rochester	1	Harvey J. Klumb	F. C. Young	Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
St. Louis	7	C. B. Fall	E. A. Forkner	Wagner Elec. Corp., 6400 Plymouth Ave., St. Louis, Mo.
San Antonio	7	D. W. Flowers	E. Bissett	San Antonio P. S. Co., 201 N. St., Mary St., San Antonio, Texas
San Francisco	8	P. B. Garrett	E. F. Maryatt	Pacific G. & E. Co., 245 Market St., San Francisco, Calif.
Saskatchewan	10	W. T. Hunt	A. B. Coward	Light and Power Dept., Regina, Sask., Canada
Schenectady	1	E. S. Henningsen	E. P. Nelson	D. C. Eng. Dept. General Elec. Co., Schenectady, N. Y.
Seattle	9	C. E. Carey	Philip D. Jennings	5560 Stuart Bldg., Seattle, Wash.
Sharon	2	S. S. Cook	R. M. Field	Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	4	J. H. Berry	Cecil Gray	Westinghouse E. & M. Co., 912 El. Bldg., Richmond, Va.
Spokane	9	Loren A. Traub	C. F. Norberg	Washington Water Pr. Co., Spokane, Wash.
Springfield, Mass	1	J. N. Alberti	L. C. Packer	Westinghouse E. & M. Co., Page Blvd., Springfield, Mass.
Syracuse	1	F. E. Verdin	Charles W. Henderson	504 University Pl., Syracuse, N. Y.
Toledo	2	F. H. Dubs	Max Neuber	1257 Fernwood Ave., Toledo, Ohio
Toronto	10	D. A. McKenzie	G. D. Floyd	Hydro El. Pr. Comm., 190 Univ. Ave., Toronto, Ont.
Urbana	5	C. E. Skroder	W. J. Putnam	123 Mat. Test. Lab. Univ. of Illinois, Urbana, Ill.
Utah	9	L. B. Fuller	Paul Ranson	Utah Apex Mining Co., Bingham Canyon, Utah
Vancouver	10	H. Vickers	C. Arnott	B. C. E. Ry. Co., Ltd., 425 Carrall St., Vancouver, B. C.
Washington	2	George W. Vinal	J. L. Carr	General Elec. Co., 800-15th St., N. W., Washington, D. C.
Worcester	1	J. K. Oldham	R. P. Bullen	General Elec. Co., Worcester, Mass.
Total 58				

STUDENT BRANCHES OF THE INSTITUTE

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Univ. of	Akron, Ohio	2	Harmon Shively	H. H. Schroeder	J. T. Walther
Alabama Poly. Inst	Auburn, Ala	4	R. Mann		W. W. Hill
Alabama, Univ. of	University, Ala	4	Walter H. Croft	Harold B. Hendrix	F. R. Maxwell, Jr.
Arizona, Univ. of	Tucson, Ariz	8	W. T. Brinton	Carl Ludy	J. C. Clark
Arkansas, Univ. of	Fayetteville, Ark	7	Ned S. Muse	E. Wylie Head	W. B. Stelzner
Armour Inst. of Tech	Chicago, Ill	5	K. A. Knittel	E. Squires	D. E. Richardson
British Columbia, Univ. of	Vancouver, B. C	10	M. A. Thomas	E. M. Kershaw	E. G. Cullwick
Brooklyn, Poly. Inst. of	Brooklyn, N. Y	3	George Morton	F. Anderson	Robin Beach
Bucknell Univ	Lewisburg, Pa	2	O. R. Sterling	P. Hort	W. K. Rhodes
Calif. Inst. of Tech	Pasadena, Calif	8	A. W. Strong	J. E. Girard	R. W. Sorensen
Calif., Univ. of	Berkeley, Calif	8	Harry C. Stanley	Louis Zable	L. E. Reukema
Carnegie Inst. of Tech	Pittsburgh, Pa	2	M. W. Smedberg	G. H. Ikola	G. Porter
Case Sch. of Ap. Science	Cleveland, Ohio	2	G. A. Sanow	Irwin J. Rand	H. B. Dates
Catholic Univ. of America	Washington, D. C	2			T. J. MacKavanagh
Cincinnati, Univ. of	Cincinnati, Ohio	2	F. F. Osterholtz	Henry Suter	W. C. Osterbrock
Clarkson College of Tech	Potsdam, N. Y	1	E. S. Whitaker	C. L. Brown	A. R. Powers
Clemson Agri. College	Clemson College, S. C	4	C. E. Jarrard	G. A. Douglass	S. R. Rhodes
Colorado, State Agri. College	Ft. Collins, Colo	6	Henry Wamboldt	L. Dougherty	F. L. Poole
Colorado, University of	Boulder, Colo	6	R. Partington	John Buffo	W. C. DuVall
Cooper Union	New York, N. Y	3	H. Grissler	A. B. Mundel	A. J. B. Fairburn
Cornell University	Ithaca, N. Y	1	C. O. Dean	Wm. E. Brainard	E. M. Strong
Denver, Univ. of	Denver, Colo	6	Harry H. Ward	Fay Olmsted	R. E. Nyswander
Detroit, Univ. of	Detroit, Michigan	5	W. R. Moyers	L. F. Ross	H. O. Warner
Drexel Inst	Philadelphia, Pa	2	E. K. Oliver	G. R. Bowers	E. O. Lange
Duke Univ	Durham, N. C	4	L. R. Ransom	A. L. de Bruyne	W. J. Seeley

STUDENT BRANCHES OF THE INSTITUTE—*Continued*

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Florida, Univ. of	Gainesville, Fla	4	C. V. Booth	E. Menendez	Joseph Weil
Georgia School of Tech	Atlanta, Ga	4	B. L. Palmer	H. A. List	T. W. Fitzgerald
Harvard University	Cambridge, Mass	1	J. H. Wright	P. R. Lincoln	C. L. Dawes
Idaho, Univ. of	Moscow, Idaho	9	F. Meneely	Clyde Ross	J. H. Johnson
Iowa State College	Ames, Iowa	5	George A. Estel	A. W. Chewning	F. E. Johnson
Iowa, State Univ. of	Iowa City, Iowa	5	J. Westley Campian	D. A. Cozine	E. B. Kurtz
Kansas State College	Manhattan, Kansas	7	H. E. Trekell	E. W. Bennett	R. G. Kloeffler
Kansas, Univ. of	Lawrence, Kansas	7	J. Warner	F. Shiner	D. C. Jackson, Jr.
Kentucky, Univ. of	Lexington, Ky	4	S. M. Worthington	B. G. Crosby, Jr	W. E. Freeman
Lafayette College	Easton, Pa	2	A. H. Edmondson	H. H. Jones	Morland King
Lehigh Univ	Bethlehem, Pa	2	P. W. Seal	L. R. Wanner	N. S. Hibshman
Lewis Inst	Chicago, Ill	5	C. B. Freilsen	K. J. Sinclair	F. A. Rogers
Louisiana State Univ	Baton Rouge, La	4	Fred H. Fenn	R. A. Crain	M. B. Voorhies
Louisville, Univ. of	Louisville, Ky	4	John G. Lips	Wm. E. Bailey	S. T. Fife
Maine, Univ. of	Orono, Maine	1	Monroe E. Moon	Lincoln O. Spencer	W. E. Barrows, Jr.
Marquette Univ	Milwaukee, Wis	5	David Becker	Edward Halback	Edward Kane
Massachusetts Inst. of Tech	Cambridge, Mass	1	G. S. Brown	Fred J. Elser	W. H. Timbie
Michigan Col. of Mining and Tech	Houghton, Mich	5	A. G. Rogers	M. D. Crowell	G. W. Swenson
Michigan State College	East Lansing, Mich	5	Robert Dearing	J. J. Clark	W. A. Murray
Michigan, Univ. of	Ann Arbor, Michigan	5	A. D. Forbes	G. Muffly	B. F. Bailey
Milwaukee, School of Eng. of	Milwaukee, Wis	5	William P. Gainer	H. F. Volkmann	Oscar Werwath
Minnesota, Univ. of	Minneapolis, Minn	5	Wesley D. Taylor	R. C. Cady	J. H. Kuhlmann
Mississippi Agri. & Mech. Col	A. & M. College, Miss	4	J. M. Leigh	J. T. Young	L. L. Patterson
Missouri School of Mines & Met	Rolla, Mo	7	J. D. Shelton	G. L. Leisher	I. H. Lovett
Missouri, Univ. of	Columbia, Mo	7	R. L. Young		M. P. Weinbach
Montana State College	Bozeman, Mont	9	Bruce Mull	Wm. McKay	J. A. Thaler
Nebraska, Univ. of	Lincoln, Nebraska	6	V. L. Bollman	W. E. Stewart	F. W. Norris
Nevada, Univ. of	Reno, Nevada	8	Francis Headley	Eugene Tucker	S. G. Palmer
Newark College of Eng	Newark, N. J	3	Wm. R. Ackor	John G. Woelking	J. C. Peet
New Hampshire, Univ. of	Durham, N. H	1	A. K. Whitcomb	Carl B. Evans	L. W. Hitchcock
New Mexico, Univ. of	Albuquerque, New Mexico	7	C. E. Henderson	S. M. Pelatowski	F. M. Denton
New York, Col. of the City of	New York, N. Y	3	Joseph Preuss	Howard Klein	Harry Baum
New York Univ	Univ. Heights, New York, N. Y	3	G. J. Helis	M. Bogstahl	J. L. Arnold
North Carolina State College	Raleigh, N. C	4	R. C. Kirk	J. H. Mauney	R. S. Fouraker
North Carolina, Univ. of	Chapel Hill, N. C	4	G. D. Thompson	Charles Hayes	J. E. Lear
North Dakota Agri. College	Fargo, N. D	6	R. Stockstad	R. Carlson	H. S. Rush
North Dakota, Univ. of	Grand Forks, N. D	6	C. J. Breitwieser	R. C. McConnell	H. F. Rice
Northeastern Univ	Boston, 17, Mass	1	A. K. Wright	P. H. Townsend	W. L. Smith
Notre Dame, Univ. of	Notre Dame, Ind	5	Earl Brieger	H. J. Perry	J. A. Caparo
Ohio Northern Univ	Ada, Ohio	2	D. Pringle	H. L. Hartman	W. Krausnick
Ohio State Univ	Columbus, Ohio	2	G. F. Leydorf	R. W. Steenrod	F. C. Caldwell
Ohio Univ	Athens, Ohio	2	H. Swigart	H. Adcock	A. A. Atkinson
Oklahoma Agri. & Mech. Col	Stillwater, Okla	7	Paul H. Foster	Merle C. Brady	A. Naeter
Oklahoma, Univ. of	Norman, Okla	7	G. S. Hammonds	William J. Fell	F. G. Tappan
Oregon State College	Corvallis, Oregon	9	H. Glen Barnett	Gordon N. Smith	F. O. McMillan
Pennsylvania State College	State College, Pa	2	S. E. McKibben	E. L. Johnston	L. A. Doggett
Pennsylvania, Univ. of	Philadelphia, Pa	2	Wm. D. Bruce	C. V. Castle	C. D. Fawcett
Pittsburgh, Univ. of	Pittsburgh, Pa	2	W. J. Howell	R. H. Kernahan	H. E. Dyche
Pratt Inst	Brooklyn, N. Y	3	J. E. Cook	J. A. Hoag	C. C. Carr
Princeton Univ	Princeton, N. J	2	F. L. Thomson	Ernest E. George	M. MacLaren
Purdue Univ	Lafayette, Ind	5	A. Simon	C. B. Bruse	A. N. Topping
Rensselaer Poly. Inst	Troy, N. Y	1	C. E Keeler	A. M. Lockie	F. M. Sebast
Rhode Island State College	Kingston, R. I	1	G. Z. Verros	M. R. Lettieri	Wm. Anderson
Rose Poly. Inst	Terre Haute, Indiana	5	Robert S. Roach	C. E. White	C. C. Knipmeyer
Rutgers Univ	New Brunswick, N. J	3	F. T. Kent, Jr	R. C. Howell	P. S. Creager
Santa Clara, Univ. of	Santa Clara, Calif	8	William Warren	L. W. Thorpe	E. F. Petersen
South Carolina, Univ. of	Columbia, S. C	4	L. E. Rankin	W. Dickerson	T. F. Ball
South Dakota State Sch. of Mines	Rapid City, S. D	6	C. Laws	A. M. Bjerke	J. O. Kammerman
South Dakota, Univ. of	Vermillion, S. D	6	Myron Cole	Carl Bauman	B. B. Brackett
Southern California, Univ. of	Los Angeles, Calif	8	A. E. Mathews	M. C. Marshall	Wm. G. Angermann
Southern Methodist Univ	Dallas, Texas	7	F. H. Gable	P. Lindsley, Jr	H. F. Huffman
Stanford Univ	Stanford University, Calif	8	V. Siegfried	G. E. J. Jamart	T. H. Morgan
Stevens Inst. of Tech	Hoboken, N. J	3	G. J. Costello	E. Starzec	F. C. Stockwell
Swarthmore College	Swarthmore, Pa	2	Lewis Fussell, Jr	Robert H. Lamey	L. Fussell
Syracuse Univ	Syracuse, N. Y	1	Donald Robinson	W. Kleppinger	C. W. Henderson
Tennessee, Univ. of	Knoxville, Tenn	4	A. M. Howery	B. A. Cogbill	J. G. Tarboux
Texas Agri. & Mech. Col	College Station, Tex	7	T. M. Sowell	E. A. Stobart	H. C. Dillingham
Texas Tech. College	Lubbock, Texas	7	Walter Burns	Everitt Dison	Wm. J. Miller
Texas, Univ. of	Austin, Texas	7	L. M. Curry	Bayron Lindley	J. A. Correll
Utah, Univ. of	Salt Lake City, Utah	9	Fred Lundberg	Ray Bohne	J. H. Hamilton
Vermont, Univ. of	Burlington, Vt	1	R. F. Bigwood	P. H. Thomas	L. P. Dickinson
Virginia Military Inst	Lexington, Va	4	G. R. Shell	C. L. Wills	S. W. Anderson
Virginia Poly. Inst	Blacksburg, Va	4	C. V. West	R. E. McDaniel	Claudius Lee
Virginia, Univ. of	University, Va	4	G. G. Quarles	T. J. Peterson	W. S. Rodman
Washington, State Col. of	Pullman, Wash	9	L. Engvall	E. W. Graf	O. E. Osburn
Washington Univ	St. Louis, Mo	7	J. Pillsbury	P. Grivet	H. G. Hake
Washington, Univ. of	Seattle, Wash	9	K. H. Ellerbeck	F. Buckman	G. L. Hoard
West Virginia Univ	Morgantown, W. Va	2	P. J. Johnson	C. F. Stewart	A. H. Forman
Wisconsin, Univ. of	Madison, Wis	5	A. G. Woodford		C. M. Jansky

STUDENT BRANCHES OF THE INSTITUTE—*Continued*

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Worcester Poly. Inst.	Worcester, Mass.	1	Albert M. Demont	William Sinclair	J. O. Phelon
Wyoming, Univ. of	Laramie, Wyo.	6	J. Earl Mowry	Cyril F. Horton	G. H. Sechrist
Yale Univ.	New Haven, Conn.	1	E. R. Eberle	L. A. Autuori	W. B. Hall
Total 107					

AFFILIATED STUDENT SOCIETY

Brown Engineering Society	Brown Univ., Providence, R. I.

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(February 1931)

Number	Author	Title
☐ 30-165	G. A. Jessop and C. A. Powell	Hydraulic and Electrical Possibilities of High-Speed, Low-Head Developments
☐ 30-173	H. M. Van Gelder	Substations of the Broad Street Subway of Philadelphia
☐ 30-174	W. W. Woodruff and G. I. Wright	Utilization of Railroad Rights-of-way for Electric Power Transmission and Coordination with Railroad Electrification
☐ 30-182	C. T. Weller	Experiences with Grounded-Neutral Y-Connected Potential Transformers on Ungrounded Systems
☐ 30-184	C. W. LaPierre	Theory of Abnormal Line-to-Neutral Transformer Voltages
☐ 30-186	A. Boyajian and O. P. McCarty	Physical Nature of Neutral Stability
☐ 30-188	R. M. Stanley and E. D. Wood	The Ohio Falls Hydroelectric Station at Louisville, Ky.
☐ 30-189	W. C. White	A Cooperative Electrolysis Survey in Louisville, Ky.
☐ 31-5	D. C. Prince and W. F. Skeats	The Oil-Blast Circuit Breaker
☐ 31-7	A. E. Kennelly	Magnetic-Circuit Units as Adopted by the International Electrotechnical Commission

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its JOURNAL publication. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name..

Address..

Please order reprints by number. *Address* **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Industrial Notes

South American Agent for Ohio Brass Company.—The Ohio Brass Company, Mansfield, Ohio, announces the appointment of Pirelli S/A, with offices in Rio de Janeiro and Sao Paulo, as Brazilian agent for that company in South America. Pirelli S/A, a branch of the Pirelli Company of Italy, large manufacturers of cables, chemicals, rubber goods, etc. maintains an extensive selling organization throughout Brazil.

General Electric Orders.—Orders received by the General Electric Company during the year 1930 amounted to $341,820,312, compared with $445,802,519 for 1929, a decrease of 23 per cent, President Gerard Swope has announced. Orders for the final quarter of 1930 amounted to $74,168,480, compared with $108,398,049 for the last quarter of 1929, a decrease of 32 per cent. As a result of the transfer of radio set and tube business, outlined in the company's 1929 annual report, orders received in 1930 do not include radio sets and tubes, except orders received for the new General Electric radios introduced in the latter part of the year.

U. S. Leads in Radio Exports.—According to a recent announcement from the Department of Commerce in Washington, more than 24,000,000 radio sets are in use throughout the world today, 45% being in the United States. Socket power sets account for 52% of the total number of sets in use in North America. In the majority of cases, outside of the United States and Canada, the cost of broadcasting is paid by a system of license fees levied on the sets in use, and these fees range from as low as thirty-nine cents in France to as high as $44 per set in Turkey. The average license fee, however, runs between $3 and $4. The United States is the world's largest exporter.

A New High Voltage Testing Set.—A highly accurate testing set of unusually flexible design, the AmerTran Type TS-15A, has been developed by by the American Transformer Company, 180 Emmet Street, Newark, N. J. This apparatus is ideally suited for light testing in either the factory or laboratory where potentials from 500 to 20,000 volts at 1 kv-a. are required. It is applicable in making accurate dielectric strength measurements on materials such as paper, tape, compound, varnished cambric, condensers, and insulation in small apparatus. The new AmerTran testing set operates from standard 110-volt, 60-cycle circuits and contains a special air-cooled testing transformer with a four-section secondary winding which permits of obtaining three different voltages at full output—5,000, 10,000 and 20,000. In addition the equipment includes a wire-wound potentiometer for adjusting the voltage to any value between zero and maximum, the exact value being indicated at all times by a precision double-range voltmeter connected to a special winding on the transformer. For protection against damage due to overload a quick-acting circuit breaker is provided. The unit is completely housed in a compact metal case on the front of which is mounted a Bakelite panel containing all operating controls.

Trade Literature

Linemen's Tools.—Bulletin 30, 68 pp. Describes a complete line of tools, belts, etc., for linemen and other electrical workers. Mathias Klein & Sons, 3200 Belmont Ave., Chicago.

Neon Glow Lamps.—Folders (2). Describe the characteristics and uses of standard neon glow lamps. General Electric Vapor Lamp Company, Hoboken, N. J.

Steam Turbines.—Bulletins GEA 1011B and 1080A, each 12 pages. Describe the design and construction of turbines for isolated plants and central stations. General Electric Company, Schenectady, N. Y.

Electroplating Aluminum.—Booklet, 36 pp., "Electroplating Aluminum." Describes the process of chromium plating and nickelplating of aluminum and alloys. Aluminum Company of America, Oliver Building, Pittsburgh.

Micarta.—Bulletin 1686-A, 16 pp., "Micarta in the Central Station." Describes Micarta insulation for power houses and substations, insulating bus bars and connections, and other applications. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Test-Signal Generator.—Catalog supplement F-200, 4 pp. Describes type 404 test-signal generator for use in comparing performances of radio receivers, or of one receiver under various conditions. This apparatus has been designed with the requirement of service testing in mind. General Radio Company, Cambridge (A), Mass.

Direct-Current Volt-Ohmmeter.—Supplement 3 to Bulletin 100. Describes a new instrument, type PD, direct-current volt-ohmmeter, which may be used for continuity testing, as a direct reading ohmmeter, or for reading voltages up to 600 volts, direct current. It is recommended by the manufacturer particularly for radio testing. Roller-Smith Company, 12 Park Place, New York.

Quadrant Electrometer.—Bulletin 330, 4 pp. Describes the "Compton quadrant electrometer." This instrument, according to the manufacturer, is probably the most delicate electrostatic instrument available, and due to its simplicity and high sensitiveness it has been widely used during the past few years in much of the best research work involving accurate electrostatic measurements. The Rubicon Company, 29 No. 6th Street, Philadelphia.

Rossman Speed Control.—Bulletin 1151, 12 pp. Describes the Rossman system of adjustable speed control which involves a method of controlling the speed of a given alternating-current drive machine over a wide speed range. It is being used with particular success for operating auxiliary equipment in large power plants. Allis-Chalmers Manufacturing Company, Milwaukee.

Lighting Panels.—Bulletin 12 pp. Describes the new "Superba" lighting panel, which is a revolutionary attempt to give attractive form to this equipment and get away from the staid straight lines of the conventional type at the same time. A more important feature is the greater flexibility and scientific design of the board from electrical and mechanical standpoints. Changes of circuit connections for both voltage and phase may be made readily without removing the door and trim or disturbing the wiring connections. These panels are composed of Bakelite units that can be furnished in a variety of colors to match background color schemes. Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit.

Electric Heating Equipment.—Catalog 247, 100 pp. Describes Westinghouse industrial heating equipment and includes operating data, charts, and tables. The catalog contains definitions of terms relating to heat treatment operations, tables for determining furnace sizes and operating costs, descriptions of different furnaces, a section devoted to installation photographs, and specifications for industrial heating appliances such as air heaters, electric glue pots, electric snow melters for track switches, and oil immersion heaters. The last section of the publication consists of a control section describing magnetic controllers, push button stations, furnace transformers, thermometers, thermostats, pyrometers, etc., making this a comprehensive and complete publication on the subject of industrial heating. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Electrical Engineering

THE

JOURNAL of the A. I. E. E.

Volume 50 MARCH, 1931 Number 3

Published Monthly by the

AMERICAN INSTITUTE
of
ELECTRICAL ENGINEERS

33 West 39th Street, New York

Copyright 1931

WILLIAM S. LEE, *President*
F. L. HUTCHINSON, *National Secretary*

PUBLICATION COMMITTEE
W. S. GORSUCH, *Chairman*
H. P. CHARLESWORTH A. E. KNOWLTON
F. L. HUTCHINSON E. B. MEYER

PUBLICATION STAFF
GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

Entered as second class matter at the N. Y. Post Office, May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

Permission is given to reprint any Institute article or paper provided full credit is given.

The Institute is not responsible for any statements made or opinions expressed in its publications.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America.

In This Issue—

Front Cover

An electric furnace in operation
—(Photo by Altwater & Bros., Pittsburgh)

Telephone and Power Practises as They Affect Inductive Coordination 176
By W. H. HARRISON, *American Telephone & Telegraph Co.*, AND A. E. SILVER, *Electric Bond & Share Co.*

Light Beams Operate Traffic Signals 182
By R. C. HITCHCOCK, *Westinghouse Electric & Manufacturing Company*

Lackawanna Electrification Improves Suburban Service 185
By EDWARD L. MORELAND, *Jackson & Moreland, Consulting Engineers*

Your Nimble Servant—The Electron 192
By KARL TAYLOR COMPTON, *President Massachusetts Institute of Technology*

Reducing Noises from Power Transformers . . . 194
By R. B. GEORGE, *Westinghouse Electric & Manufacturing Company*

What of Surplus Power? 197
By FARLEY G. CLARK, *Consulting Engineer*

Cooperative Work on Joint Pole Use 203
By J. C. MARTIN, *Middle West Utilities Company, and* H. L. HUBER, *American Telephone & Telegraph Company*

—Turn to Next Page—

Reactance Relay Performance Reviewed . . . 205

By E. E. George, *Tennessee Electric Power Company*

Electrical Porcelain 209

By H. M. Kraner, *Westinghouse Electric & Manufacturing Company*

Hydrogen Cooling for Turbine-Generators . . . 211

By M. D. Ross, *Westinghouse Electric & Manufacturing Company*

President Lee Answers Governor Pinchot . . . 215

A Telegram and a Letter

News of Institute and Related Activities ◆ ◆ ◆ ◆ 216

Local Institute Meetings 233

Employment Notes 239

Membership 241

Engineering Literature 242

Officers and Committees 248

Industrial Notes 252

The Edison Medal for 1930 was presented January 28 to Dr. Frank Conrad by W. S. Lee, president of the Institute, following a eulogy effectively delivered by Dr. Chas. F. Scott, past-president and 1929 Edison medalist. *(See page 216)*

◆

Karl Taylor Compton, president of the Massachusetts Institute of Technology, characterized the electron as mankind's most nimble and effective servant in his demonstration lecture at one of the Institute's winter convention sessions. Dr. Compton did not attempt to reveal anything new and startling concerning the electron, but he did outline rather comprehensively the present status of scientific understanding of that most minute and highly animated particle of matter. *(See page 192)*

Protective relays and related automatic devices are correctly accredited with having done much to make possible long distance power transmission and to facilitate the handling of the great electric power concentrations required to meet ever-growing demands. Everett E. George describes the reactance relay installation of the Tennessee Electric Power Company, one of the first and most extensive applications of this relatively new device. Operating experiences are outlined in order that others may profit thereby. *(See page 205)*

◆

Some of the mysteries of electrical porcelain are reduced to a far less serious proportion by a brief discussion of chemistry, materials, and manufacturing methods given by H. M. Kraner. *(See page 209)*

Farley Granger Clark (A '01; M '12; F '13) is the ardent proponent of a rather comprehensive plan for improving the operating economies of electric power systems through definite efforts to provide an outlet for "surplus" power. Mr. Clark suggests that surplus power available from existing generating stations at other than peak-load periods can well be absorbed in various industrial and particularly electrolytic processes involved in the manufacture of many commodities, including fuel gas. Mr. Clark graduated from Cornell University in mechanical engineering, class of '94; from 1897 until 1902 he was with the Metropolitan Street Railway Company (N. Y.); 1903-4 with Westinghouse, Church, Kerr & Company (N. Y.); 1905-10 with the Pennsylvania Railroad; 1911 with the Westinghouse Company; 1912-22 chief engineer of the Toronto (Canada) Power Company and affiliates. Since 1923 he has been in private consulting practise. *(See page 197)*

◆

Another phase of the cooperative work of the communication and the electric service utilities in the interest of improved service to customers, revolves around the joint use of poles for the lines of the two utilities. J. C. Martin of the Middle West Utilities Company, and H. L. Huber of the American Telephone and Telegraph Company, each a transmission authority in his own field, have jointly produced a comprehensive outline of the present situation and current trends as regard cooperative work on joint pole use. *(See page 203)*

◆

The winter convention technical sessions with their wealth of material as represented by some fifty papers are comprehensively "covered" in ten news items. Some of the extensive discussion at four of the sessions is summarized; some further discussions will be presented in a subsequent issue. *(See pages 216-228)*

One of the most interesting factors influencing the trend of development of large electric generators, synchronous condensers, and similar rotating equipment, is the advent of hydrogen gas as a cooling medium. M. D. Ross, associated with the development of this type of equipment for the Westinghouse company, describes some of the problems and outlines some of the possibilities. *(See page 211)*

Pittsburgh, Pa., where the American Institute of Electrical Engineers will convene March 11-13, 1931, for a regular meeting of the Middle Eastern District (No. 2). For the news story of this meeting see the April issue of ELECTRICAL ENGINEERING

NOISE REDUCTION is being aggressively pushed from many different angles. R. B. GEORGE of the Westinghouse company describes experiments in controlling and reducing unpleasant noises emanating from power transformers and makes useful suggestions. *(See page 194)*

◆

TRAFFIC CONTROL, a vexing problem affecting an ever-increasing percentage of the general public, bids fair to be simplified greatly through ingenious applications of that most versatile device, the electron tube. R. C. HITCHCOCK, Westinghouse research engineer, describes some successful practical experiments in the use of light beams to operate traffic signals. *(See page 182)*

◆

WITH THE RECENT announcement of the Pennsylvania Railroad that it would proceed at once to complete the electrification of its main lines between New York City and Washington, D. C., and the announcement of electrification projects contemplated by other large railway systems, the question of railway electrification is assuming ever greater importance in engineering and economic circles. EDWARD L. MORELAND, well known consulting engineer and partner in the firm of Jackson & Moreland, Boston, who personally supervised the most important phases of the recently completed extensive electrification of the Lackawanna suburban lines serving New York City and New Jersey territory, discusses the important features of the project, several of which have established new precedents in the art. *(See page 185)*

◆

WILLIAM STATES LEE (A '04; M '03; F '13) active, competent, and aggressive president of the Institute, answers in detail a lengthy telegram from the Honorable Gifford Pinchot, governor of the commonwealth of Pennsylvania. In his letter, President Lee corrects certain misunderstandings which were evidenced by the telegram which Governor Pinchot sent under date of January 28 addressed jointly to President Lee and the winter convention assemblage of the Institute. *(See page 215)*

FOR THE FIRST TIME in so comprehensive a manner, the present trends in telephone and power practises as they affect inductive coordination are set forth, so that all who are interested may know something of the more important factors underlying the important engineering cooperative efforts between the communication and the electric service communities. W. H. HARRISON, American Telephone and Telegraph Company authority on the subject, and A. E. SILVER of the Electric Bond & Share Company representing the electric service utilities, not only are well qualified to discuss the subject but represent also tremendous aggregations of engineering ability. *(See page 176)*

◆

WILLIAM J. FOSTER of Schenectady, N. Y., has been awarded the Institute's Lamme medal which will be presented during the summer convention at Asheville, N. C., June 22-26, 1931. Dr. Foster receives the award "for his contributions to the design of rotating alternating-current machinery." *(See page 229)*

Telephone and Power Practises As They Affect Inductive Coordination

Proper coordination of parallel power and telephone circuits to control the noise induced in the latter is one of the oldest and most important problems requiring the joint consideration of power and telephone companies throughout the United States. Progress in the development of the telephone and power industries to meet growth and improve service, has an important influence on problems of coordination. Important trends and their influence are summarized in this paper.

By W. H. Harrison *and* *A. E. Silver*
Member A. I. E. E. — Fellow A. I. E. E.
American Tel. and Tel. Company, New York — Electric Bond & Share Co., New York

THE MANY important benefits resulting from the cooperative handling of questions arising from the proximity of the lines of the telephone and electric power systems of the United States are emphasized by the extent and the rapid growth of these two industries. Such a rate of growth (see accompanying illustrations) necessarily brings with it many cases of physical proximity where, because of the widely different characteristics of the circuits involved, difficulties might arise. The necessity for active study of the coordination of the different systems and for the current handling of large numbers of individual situations will continue for a long time to come.

In approaching the technical phases of the subject of coordination it seems well to emphasize the fact that, after all, the power and telephone companies serve essentially the same customers, and thus it is essential that both services be rendered in the most economical manner. Each utility, therefore, should construct its plant with full regard for the plans and facilities of the other.

The Joint General Committee of the National Electric Light Association and the Bell Telephone System has recommended principles and practises which recognize these fundamental factors and which point the way to the practical handling of each type of situation. In effect, each individual situation is contemplated to be worked out on the basis of the best over-all engineering solution, just as if both utilities were under one management. Without this basis of procedure it is hard to visualize how, with the service density of both utilities steadily mounting and with both the services rapidly extending into new territory, it would be possible to carry on these extensions in the present orderly fashion.

In the following are outlined some of the more important developments in the telephone and power industries, together with their effects upon coordination problems.

Perhaps the most important of these developments in both the power and telephone fields have to do with constant improvement in the quality of service afforded to customers. This trend is exemplified in the power system by fewer service interruptions, better voltage regulation, and better frequency regulation. In the telephone system this progress is marked primarily by the generally improved characteristics of transmitted speech and faster and more reliable service; secondarily, by a tremendous extension and widened scope of direct-connected voice communication channels.

In the telephone system the improvement in standards of service, if considered by itself, tends to increase the noticeability of inductive effects from outside sources. Similarly, increases in the extent of service and speed of completing calls have led to increased reliance on prompt telephone communication, tending to increase the importance of avoiding interruptions. Five years ago the average interval of time between the placing of a long distance toll call by a subscriber and the commencing of the conversation was 7½ minutes; at the present time it is a little less than 2½ minutes.

The improvement of service has been associated with a particularly rapid growth of very "long haul" telephone business and a consequent increase in the average length of telephone circuits used for interurban and long distance work. In the period 1925-29, while telephone toll business as a whole increased 59 per cent, New York-Chicago business increased 170 per cent and the combined Chicago and New York business to Los Angeles and San Francisco, 380 per cent. From the standpoint of coordination with other electric circuits the very long telephone circuit offers a more difficult problem than the circuit of moderate length because of the cumulative effect of exposures in different sections.

In the power industry one of the most important items in the improvement of service has been the steady decrease in the number of service interruptions. This has

---

From "Trends in Telephone and Power Practise as Affecting Coordination," (No. 31-21) presented at the A. I. E. E. winter convention, January 26-30, 1931, as Part 1 of a symposium on coordination of power and telephone plant.

been brought about mainly by better standards of construction including more systematic mechanical and electrical arrangement of circuits and apparatus, and increased numbers of circuits and sources of supply. While the increasing numbers of interconnecting and other types of lines bring new conditions requiring coordination of power and telephone plants, improved construction and increased security of circuits and apparatus have a definitely beneficial effect upon matters of coordination by reducing the number of abnormal conditions of operation. Better voltage regulation and certain accompanying factors which definitely aid coordination include better balance of currents in the separate phases of the circuits and more effective arrangements minimizing the tendency of currents to flow in the earth.

While in some respects the extent and rapid growth of the two utilities and the improvement of service standards have tended to increase the importance and the difficulties of coordination work, these adverse tendencies have been offset by beneficial effects of improvements in plant design and construction and by the cooperative endeavor which has been carried on by the two utilities during recent years. It is a tribute to the effectiveness of this cooperative work that the degree of satisfactory coordination between the two systems is steadily improving.

In the following pages brief statements are made descriptive of the more important trends in the respective systems.

Trends in Telephone Practise

Present trends in telephone system include:

1. Dial system.
2. Extension of toll cable.
3. Increased use of telephone repeaters.
4. Carrier telephone systems.
5. Improved station apparatus.
6. Connections to foreign countries.

Extensions in the telephone toll system and improvements in the service generally, tend to increase the number of coordination problems and their importance. Extended use of toll cable tends to reduce these same problems, since cable is less susceptive than open wire and its use allows many more circuits to be carried over a single route, thereby reducing the number of routes.

Probably the most fundamental and far reaching of these changes is the progress of conversion from manual to dial system operation. When present plans are completed approximately 80 per cent of the telephones of the Bell System will operate on a dial basis. While this trend is of the greatest and most fundamental importance in the development of the telephone business it does not affect the coordination problem in any material way and therefore need not be further discussed here.

One of the most spectacular trends of development of the Bell System at the present time is the increase in the connections to foreign countries. Earlier connections to Canada and Cuba were supplemented in 1927 by service to Mexico and by transoceanic radio links from New York to London through which connection is made to the principal European countries; and in 1930 a similar radio link from New York to Buenos Aires through which connection is made to Montevideo, Uruguay, and Santiago, Chile. During the next few years it is expected that these foreign connections will increase to include all important points in South America, Australia, Japan, Honolulu, and all other points which may offer an appreciable demand for service. These intercontinental circuits are not directly affected by the physical proximity of power circuits; but their efficiency is affected by noise currents on connected circuits.

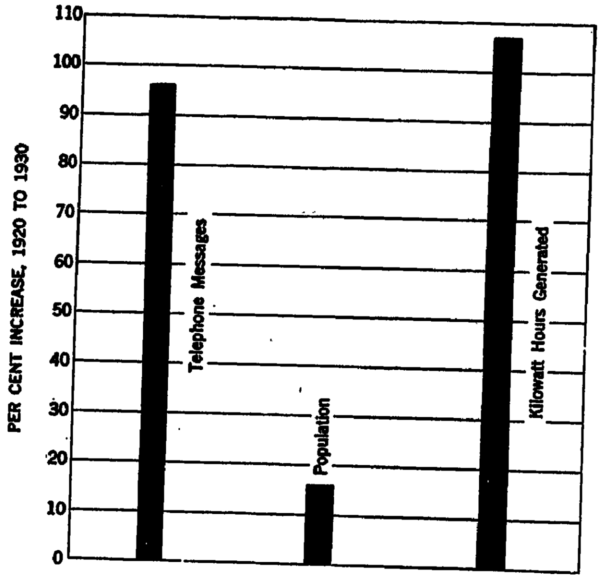


Fig. 1. Growth in the utilization of power and telephone service as compared to growth in population for the period 1920-1930, expressed in percentage of increase

Toll Cable Increasing

The change in methods of designing and constructing toll circuits which is of greatest importance is the great increase in use of cables for such circuits, including both the very long distance circuits and the shorter interurban circuits. A single cable may provide from 250 to 500 telephone circuits and several hundred telegraph circuits, as many circuits as would be supplied by from five to ten heavily loaded open-wire pole lines.

This concentration of circuits in a single cable, a number of which can be placed on a single route, of itself greatly simplifies coordination problems by materially reducing the number of routes involved.

Furthermore, the presence of the lead sheath with the twisting of the cable conductors, the high degree of balance with respect to ground, and the mutual shielding effect of the many circuits in one cable, practically prevent the direct induction of noise currents into the cable circuits from outside electrical sources. The shielding effect of the lead sheath when suitably grounded also provides substantial reductions in the voltages of fundamental frequency which may be induced along the cable conductors at time of trouble on neighboring power systems.

A telephone toll cable with its associated equipment costs about the same per mile as a twin-circuit power transmission line of the 110-kv. class. This high cost has led to a large use of private rights-of-way for new extensions of these cables, particularly for aerial cable construction—an added advantage from the coordination standpoint.

In all types of cable construction the susceptiveness to noise induction is so greatly reduced that low frequency induction generally becomes the limiting factor relative to the permissible proximity of these cables to power circuits. The relative amounts of induced voltages occurring with certain types of cable construction as compared with open-wire construction are in the order of 1:5.

While as noted cable circuits are protected effectively from noise induction, the efficiency obtainable over the long circuits is limited in part by the noise currents occurring in the open-wire lines which may be switched to the long cable circuits. This is because the efficiency of the long cable circuits depends upon voice-operated switching devices which must not be operated by the noise currents. This is true also of the intercontinental circuits. Extension of the circuits controlled by voice-operated devices therefore tends to increase the importance of good coordination of the entire plant.

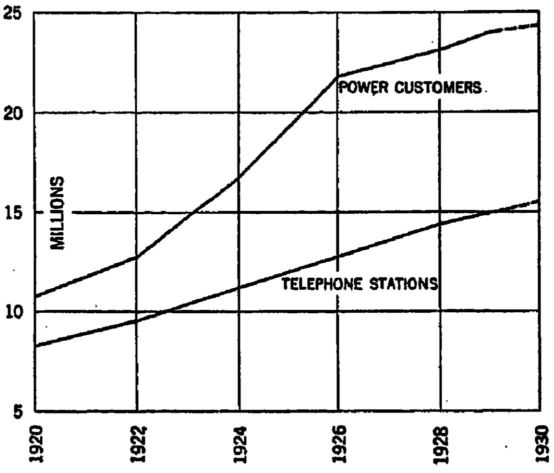


Fig. 2. Growth in the number of telephone subscriber stations and electric power customers for the decade 1920-1930

Repeaters and Carrier Systems

Another important trend of practise is the wide use of telephone repeaters, the purpose of which is to amplify the voice currents and thus make possible higher efficiency and greater extension of long distance telephone circuits. Without repeaters it was necessary on the long open-wire circuits to permit the power level of voice currents to sink to relatively low values. An extreme example of this is given by the New York-Denver circuit which, before repeaters were available for use, had an over-all ratio of output power to input power of 8:10,000. With the application of repeaters, the level of voice currents can be kept relatively high throughout the circuit.

The use of repeaters thus contributes to reducing the susceptiveness of the telephone plant and aids coordination. On a circuit such as the original New York-Denver circuit a relatively small amount of noise current greatly impaired transmission because of the weak incoming voice currents.

A third important trend in telephone practise is the extension in the use of carrier telephone systems for long circuits and the associated changes in aerial wire construction practises. The carrier systems are much less influenced by noise induction from power circuits because they occupy a range of frequencies (5,000 to 30,000 cycles) in which the harmonic power voltages or currents ordinarily are extremely small.

Subscribers' Station Apparatus

To a great extent the trend of development in subscribers' station apparatus is toward new arrangements which provide fuller convenience and more closely meet the needs of the users, and which have no material effect upon the coordination problem. An important group of developments, however, centers about the improvements in electrical performance of station apparatus accomplished by removing impairments caused by the earlier types of apparatus. These changes, by improving the quality of speech as reproduced by the telephone system, tend to make more noticeable the impairments caused by the effects of currents induced from external sources.

The tendency toward an increase in the range of voice frequencies efficiently reproduced by the telephone system tends to increase also the range of induced currents which may cause noise interference. An extreme illustration of this is represented by the circuits designed to transmit programs for radio broadcasting stations. Transmission characteristics of these circuits have been improved to accommodate efficient transmission of currents of frequencies ranging from 35 to 8,000 cycles per second. Thus these circuits are susceptible to inductive noises over this same wide range.

Room noise at subscribers' premises, besides acting directly on the ears of the telephone user, is converted by the transmitter into electrical currents which in turn produce receiver noise. Efforts now being made to reduce these effects inevitably will tend to bring into increasing prominence noises caused by induction which now in many cases are partially overshadowed by reproduction of room noises.

To offset this tendency, at least partly, steps have been taken to improve the degree of balance-to-ground of new station apparatus, particularly in the case of party lines.

OTHER ITEMS

Other features not directly associated with these trends, and introduced into the telephone plant largely because of the advantages to be gained in reducing susceptiveness to electrical influences, have afforded other benefits also. Interesting examples of these changes include recent adoption of soldered joints to replace twisted sleeve joints and the substitution of copper for iron wire on short tributary toll circuits. In toll offices improvements have been made in the balance of coils and condensers used for superposing telegraph on the telephone circuits. The use of repeating coils, commonly used for side-circuits, has been extended to phantom toll circuits. These coils act as insulating transformers to prevent noise voltages from the outside conductors being impressed upon the intricate cabling and equipment of the office.

Referring to the local plant, there are several noteworthy examples of modifications made principally for the purpose of reducing susceptiveness. Coordination investigations such as were conducted at Minneapolis by the joint general committee have stimulated the development of means for reducing the susceptiveness of the telephone distribution plant.

With the rapid increase of voltage and capacity of power circuits generally, experimental studies have been undertaken to ascertain further means of maintaining the safety of persons working or listening on telephone circuits. At the present time, development work is under way on various devices for this purpose, some of which are fundamentally different in design and operation from those previously used. It is hoped that these devices will afford increased protection against over voltages and improve coordination and conditions.

TRENDS IN POWER PRACTISE

Current trends in power system development include:

1. Interconnection of large systems.
2. Higher transmission and distribution voltages.
3. Larger generating units.
4. Improved system stability.
5. Control of the effects of lightning.
6. Underground construction.
7. Improved wave shape.
8. Increasing use of automatic devices.
9. Better frequency regulation.
10. Better voltage regulation.

The first three items are likely to increase the number of coordination problems and make certain of them more difficult; distinct help in reducing the coordination problem is afforded by Items 4-7 inclusive; the last three may be said to be beneficial but of less importance.

Those trends in power system development which are more directly concerned with matters of coordination are discussed in the following paragraphs.

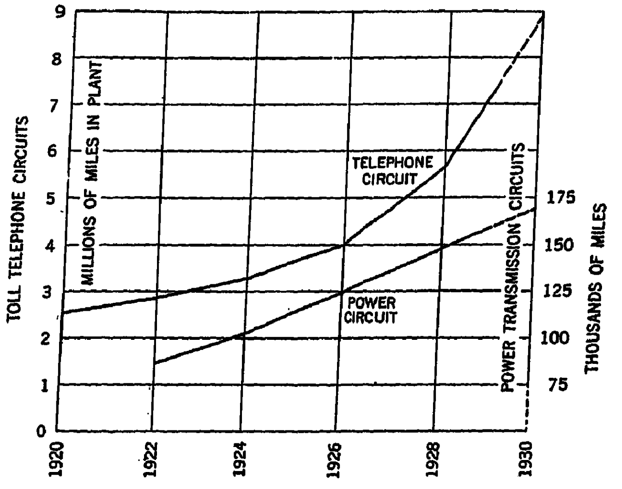


Fig. 3. Record of a ten years' growth in mileage of long distance telephone toll circuits and electric power transmission circuits of 11 kv. and higher. Telephone circuit mileage is given in millions; power circuit mileage in thousands

SYSTEM VOLTAGES

Statistics show that the rate of increase of transmission line mileage, as a whole, is lagging behind the rate of growth of both installed generator capacity and electricity production. Furthermore, mileages of the higher transmission voltages (220 kv., 132 kv., 110 kv., and particularly 66 kv.) are growing at a more rapid rate than the group average. These comparisons reflect the increasing utilization of the higher voltages with the greater circuit capacities they provide.

In the distribution field also, coincident with the development of rural service, there is a movement toward higher voltages in primary circuits. Voltages from 6.6 kv. to 13.2 kv. and higher have been used in rural work. In urban areas the high load densities encountered have brought about replacement of the lower by higher primary voltages. In addition to the greater capacities provided by the higher voltages, possibilities of system simplification by combining rural and urban systems to eliminate voltage transformations are of considerable economic importance.

While at first glance the pronounced trend to higher transmission and primary distribution voltages may appear to enhance the difficulties of coordinating communication and power lines, certain offsetting factors enter. As transmission voltages increase there is a definite trend toward direct cross-country private rights-of-way which automatically provide greater separation from communication circuits.

In the case of distribution lines, too, the adoption of increasingly higher voltages is accompanied by more systematic grades of construction and greater clearances from communication circuits. The result of course is that fewer abnormal conditions of operation occur and the number of related disturbances in the communication circuits is reduced correspondingly.

SYSTEM STABILITY

During recent years considerable attention has been paid to the development of methods for improving system electrical stability. One of the most important of these methods is the use of higher speeds of switching,—at present, faults can be cleared in 15 cycles, or less, of a 60-cycle wave. So far, high-speed switching has been applied mainly to transmission circuits. However, as development proceeds and cost of equipment required is reduced, the field of application of high-speed switching may be extended to distribution systems. The result in the case of either transmission or distribution will be of course to reduce the duration of transients.

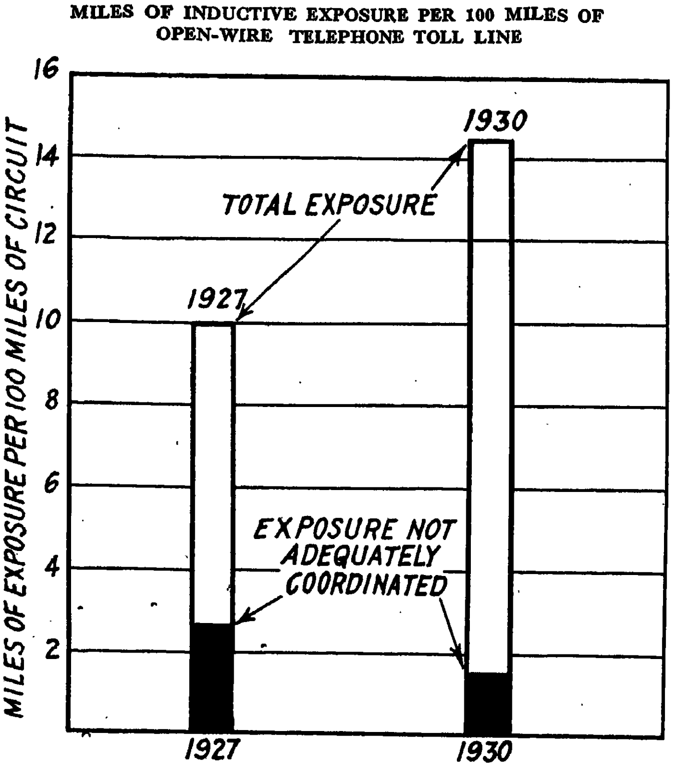


Fig. 4. Concrete evidence of the beneficial effect of the methods developed through the joint efforts of the power and telephone industries

Akin to high-speed switching, the use of high-speed excitation of rotating equipment has been developed. This may tend to increase the maximum fault-current values somewhat, which would make coordination more difficult. However, the reduction in severity of instability surges, in so far as such surges involve faults to ground, affords definite benefits from the coordination standpoint. Further study and observations are required to determine what, if any, inherent limitations or advantages high-speed switching may possess with respect to coordination work.

With the growth in power systems and major interconnections, the use of bus or feeder current-limiting reactors or other means of limiting the concentration of fault-current flow is being given increasing application. Such practise acts to restrict the magnitude of inductive transients. In distribution systems the growing use of feeder reactors has a similar effect upon coordination.

It is predominant practise in America to ground the neutrals of transmission systems at important transforming centers, sometimes through resistors or reactors, but usually solidly; thus, a large proportion of the transformers of higher voltages now in service have insulation between the neutral ends of the grounded windings and the core designed to withstand only the neutral potentials produced by fault currents regulating through the unavoidable impedance of grounding connections. Economies resulting from this method of construction become greater as rated operating voltages rise. However, the use of solidly grounded neutrals tends to make coordination more difficult in view of the possibilities for increased flow of earth currents. Increasing study and consideration are being given to the use of current-limiting devices in the neutral where the characteristics of the apparatus and limitations of relaying will permit such operation. The increasing use of neutral impedances and other types of current-limiting devices aids coordination through reduction in the magnitude of abnormal induction.

LIGHTNING CONTROL

The major problem of the transmission art at the present time is the control of lightning in its effects on service. In those sections of the country in which lightning is prevalent, this natural hazard accounts for a large proportion of transmission circuit faults, approaching 100 per cent for the higher classes of trunk transmission lines. Present measures directed toward the control of service interruptions caused by lightning include improved application of overhead ground wires, improved grounding connections at the supporting structures, greater use of wood for lightning insulation, the use in shunt with line insulators of fused gaps, or other valve devices to "spill" the surge without dynamic current follow-up. There is under consideration also the application on grounded-neutral systems of single-phase switching. All of these measures, with the exception of the last, are helpful from the coordination point of view since their effect is to avoid or reduce system faults or at least to decrease the magnitude of earth fault currents and hence, of the accompanying voltages induced in nearby communication circuits.

UNDERGROUND CONSTRUCTION

Underground construction in distribution systems seldom is economical; but it is increasing in high-load-density districts and in some residential areas primarily in response to requirements for civic improvements and the relieving of surface congestion. Coincident with the more recent developments in underground distribution, certain special situations have brought about the development of underground cable suitable for use in high-voltage transmission circuits, including 132-kv. Underground installations involving these transmission voltages are comparatively few in number and small in extent. Underground construction of both distribution and transmission circuits has a definitely favorable effect upon coordination problems.

Aerial cable construction for both distribution and transmission circuits has been used to a limited extent and has a definitely beneficial effect upon coordination matters. Whether this type of construction will be extended in the future is not evident.

GROUNDING OF DISTRIBUTION SYSTEM NEUTRALS

Because of the difficulties encountered in distribution systems in obtaining adequate grounding of primary and secondary circuits, the establishment of neutral networks grounded at many points has become a practise. In most past cases separate primary and secondary networks have been provided, but recently in several localities, the two have been combined into a common-neutral arrangement providing increased multiplicity of ground connections. Wider use of the system is probable.

This common-neutral arrangement introduces features of interest from the coordination standpoint, because of the increased opportunities for the flow of currents through the ground. Experience and investigations so far, however, indicate that with adequate attention to coordination, this arrangement is comparable in its effect on neighboring communication circuits to other types of distribution systems.

WAVE SHAPE

Connection of primary circuits directly to generating station buses results in service and economic advantages through elimination of transformations, thereby improving voltage regulation and aiding system simplification. This practise, however, tends to make coordination more difficult because harmonics which may be present in the generated voltage can flow directly out over such circuits. However, the important bearing of generator and apparatus wave shape upon the coordination problem long has been realized and is receiving increasing attention.

It is recognized that there is a median beyond which, (to avoid the alternative of applying in specific cases available and less expensive methods of externally correcting wave shape,) general improvement in the inherent wave shape of apparatus would not justify the attendant increased difficulties of design and increased manufacturing costs. Looking toward establishing a measure of wave shape in apparatus design which will strike an economic balance between benefits and burdens, work is now in progress cooperatively between the manufacturers and the users.

Increasing use of rectifiers for conversion from alternating to direct current also has an influence on inductive coordination. Study devoted to this matter has revealed methods for control of the distortion of the d-c. voltage wave caused by the rectifiers, and a solution of this part of the problem appears to be in hand. Progress in the design and application of apparatus, and the better understanding of the influence of circuit and transformer connections on inductive relations, indicate that problems concerned with wave shape may be expected to decrease steadily.

CONCLUSIONS

In reviewing this subject one is impressed by the number of ways in which the coordination problem touches both the telephone and power fields, and with the very large amount of cooperative work which already has been done. This work, as has been indicated, has resulted in noteworthy progress in the satisfactory handling of coordination matters of all characters. The situation concerns two industries which are in a period of rapid development and change, both as regards their size and as regards the physical arrangements which constitute their plants. Many new developments in each plant require consideration from the standpoint of coordination.

It is evident, therefore, that if the ground already gained is to be held, and further progress made, the channels of cooperation between the two industries must be kept in operation for the consideration of new problems arising with new developments in the industries, as well as for the further perfection of the cooperative methods of handling existing specific problems.

Light Beams Operate Traffic Signals

Efforts to perfect automatic devices which will give major highways a green light at all times except as change is actually required by traffic on minor intersecting streets now have turned to the grid-glow and photoelectric tubes. Operating experiences gained from trial installations are discussed and equipment features are outlined.

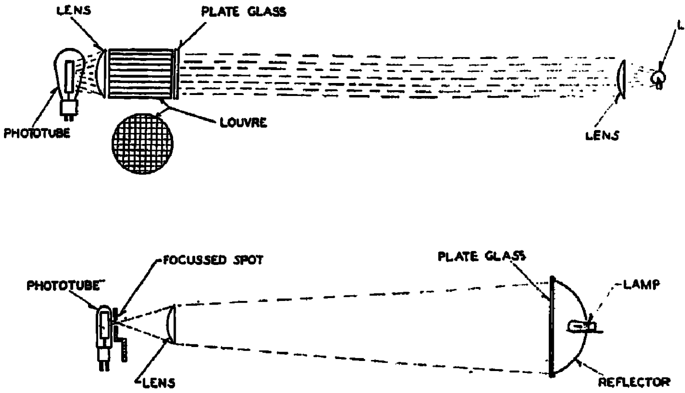


Fig. 1. Optical systems showing light-beam transmitting and receiving apparatus: (above) second installation; (below) third, improved installation

By R. C. Hitchcock

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

TRAFFIC CONTROL at intersections of streets carrying light traffic with streets or boulevards carrying through-city or cross-country traffic presents one of the most perplexing problems with which police departments and other traffic controlling bodies have to deal. The problem is complicated still further when it is considered that the ratio of major traffic to minor traffic may vary as much as from 3:1 to as high as 50:1, or even higher on some occasions, at the same intersection.

Devices employing photoelectric and grid-glow tubes actuated by light beams provide automatic adjustment of signal operation to traffic requirements by maintaining a green or "go" signal on the major traffic street at all times when there is no traffic on a minor intersecting street.

Devices actuated by traffic on both of the intersecting streets are in use in some locations, with no special signal program. Such equipment must be very carefully designed and frequently inspected, for should failure occur in any unit, signals may remain as they were at the time of failure. With the major-minor device described here, the failure of any of several units causes the vehicle-controlled light-beam device to be disconnected automatically, and the regular timer motor which is incorporated into the apparatus, to then control the traffic at the intersection on a predetermined cycle.

As an example showing how, this system may be applied to a typical major-minor intersection, assume a one-minute traffic cycle with a timing of: 42 sec. major street green, 3 sec. amber, 12 sec. minor street green, and 3 sec. amber. Thus the ratio of green light for major and minor streets is 42:12 or 3.5:1; yet this timing is frequently used at an intersection where the traffic ratio ranges from 10:1 to 50:1, and where 1,000 or more cars per hour are passing on the major street. The reason for the short major cycle is to allow the minor street vehicles to enter the intersection after a maximum waiting time of 45 sec. All this is done with the new automatic controller; at the same time the major street is allowed as much more than a 42-sec. green-signal period as the minor traffic permits.* In addition, after the first 45 sec. of major street green, the minor traffic wait is only about 5 sec., or just long enough for the automatic device to function.

EARLY EXPERIMENTAL INSTALLATIONS

During the early development work on this apparatus, in order to study the performance of the devices under actual operating conditions two trial installations were made at minor intersections.

Fig. 2. Location of control units at intersection of minor street with William Penn—Lincoln Highway, Wilkinsburg, Pa.

---

* From "Traffic Control by Light Beams," (No. 31-34), presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

In the first installation vertical light beams were used; but so much difficulty was experienced with grease and dirt falling on parts of the apparatus mounted below the street surface that this installation soon was discontinued. In subsequent installations a horizontal light beam has been used, placed at such a height that it can be operated by any type of vehicle now on the market. The optical system used in the second installation is shown in Fig. 1; as may be noted, a lens system focussed an image of the lamp filament on the photoelectric cell through a louver. This louver consisted of a square, sectional honeycomb which passed light parallel to its axis but prevented the passage of light entering at an angle of even a few degrees.

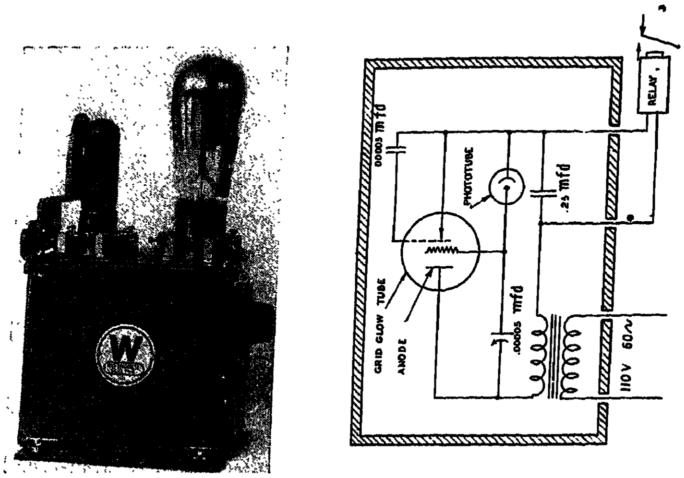


Fig. 4. Grid-glow phototube unit showing schematic wiring diagram and complete assembly of device

One interesting problem encountered during early experiments was the operation of the signals by cars making turns from the major into the minor streets. Thus a green light would be given to the minor street with no traffic waiting for it. This problem was solved by introducing a time-delay relay into the light beam operating circuit. This relay was timed so as to require an approaching vehicle to intercept the light beam for several seconds before a change of signal lights took place. In this way no change of signal lights such as those caused by vehicles making turns resulted from momentary interruptions to the light beam.

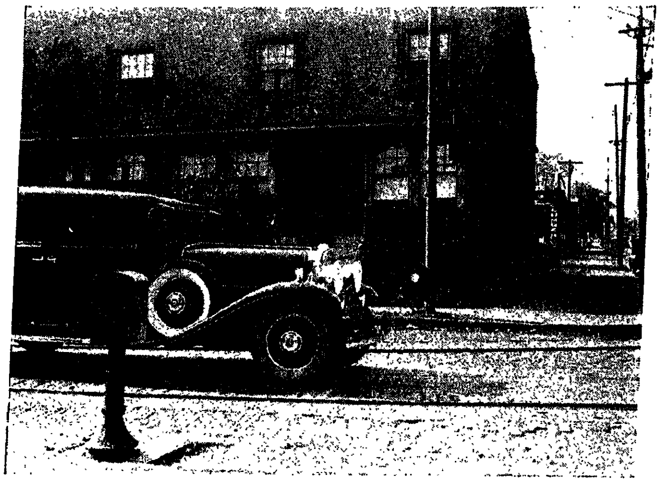


Fig. 3. Vehicle intercepting horizontal light beam

Unusual reliability for a device still in the development stage was demonstrated by this second installation. After five months' operation only three interruptions have occurred—two of these due to dirty lenses and resulting from the apparatus going on "program" operation; and the third due to a loose connection which resulted in one relay box being out of service for about two hours. Also during this period, one of the lamps in this installation for 4⅓ months burned out and after 4½ months one of the original glow tubes was replaced.

THIRD INSTALLATION

With certain changes as dictated by operating experiences with the second installation, a third set of apparatus was built and installed in Wilkinsburg, Pa., at the intersection of a minor street with the street which carries traffic from both the William Penn and Lincoln highways through the town. This installation was completed on September 16, 1930. Location of the control boxes at this intersection is shown in

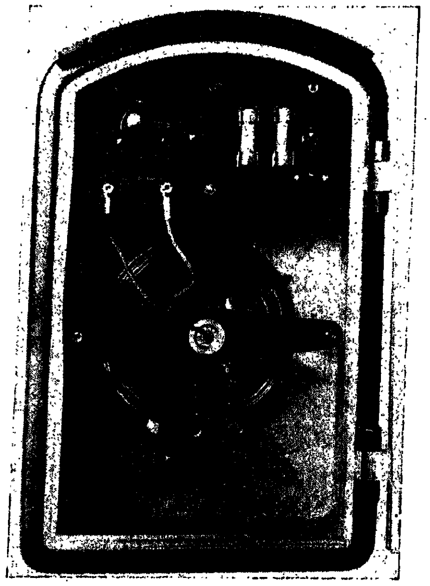


Fig. 5. Rear of reflector unit showing lamp mounting, rheostat, and switch

Fig. 2. A vehicle intercepting the light beam in one set of these units is shown in Fig. 3.

Fig. 4 shows the grid-glow phototube unit used in the third installation. Paraffin-impregnated cork washers together with a special clamping device were found to keep the tube bases free from moisture and dirt. Both the transformer and condensers with their associated wiring are contained inside of a small casting, as shown. The upper panel is made of moldarta and is screwed to the casting with a paraffin-cork gasket to keep it moisture-tight. The no-load loss of the transformer provides sufficient heat to prevent condensation of moisture within this casting. In this connection, tests were made with the grid-glow phototube unit in a humidifier. With the humidity at 100 per cent, water was sprayed over the unit several times. Under these extreme conditions the paraffin-cork washers and gaskets held their seal and the unit operated satisfacfactorily for several hours.

The complete optical system of the third installation is shown in Fig. 1. With the exception of the front the glass of the phototube is painted black. This keeps daylight out of the tube so that with the back of the control box open adjustments may readily be made. As may be noted in both Figs. 1 and 4, a shield containing a small hole on which the light source is focussed, is placed in front of the phototube, thereby keeping out extraneous light.

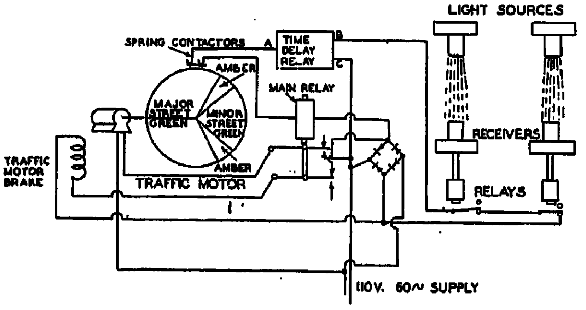


Fig. 6. Schematic diagram of latest installation

Experimental results indicate that a fairly good parabolic reflector such as used in this third installation is better than any reasonable-priced lens of similar diameter as used in the second installation. As a result of this improved optical system, lower lamp filament currents may be employed; this in turn means longer life for lamps. A rear view showing the reflector of the lamp-unit box may be seen in Fig. 5. The lamp socket has two knurled clamp nuts which allow motion of the socket in and out, while a large hole in the support permits lateral motion. A resistor is provided in series with the primary of the lamp transformer so that its voltage may be varied to suit.

Schematic wiring diagram for the third controller is given in Fig. 6. As shown in this diagram the major street signal is green, the main relay is pulled up, power is off the motor, and the brake is on. When a car crosses the light beam momentarily as in turning from the major into the minor street, the light-controlled relays pull up, and the circuit wires *A* and *B* of the time-delay relay are open-circuited. However, unless the car remains in the beam for the specified time delay there is no further action in the controller. But if a car does wait in the beam for the specified time, circuit *A-B* remains open, the traffic motor starts up, and the cycle begins, giving amber and then green to the minor street.

Arrangement of parts in the main control unit is shown in Fig. 7. This view shows the rear of the box at the top of which may be seen some of the time-delay apparatus. Of particular interest is the method of mounting the grid-glow-phototube unit which can be seen at the bottom of the box.

Fig. 7. Rear of main-control box containing grid-glow phototube unit and time-delay apparatus

It is interesting to note that at the time of writing this third installation has been in operation for about one month and no service interruptions have occurred. By actual timing, the major street has been found to receive a green signal for periods as long as five minutes at times of extremely light traffic on the minor street.

Operations described in the foregoing paragraphs have been accomplished purely experimentally; the equipment is not available for commercial usages.

CONCLUSIONS

In summing up the results so far obtained with these devices it may be said that:

1. The red light was flashed on the major street from 50 to 70 per cent less than when using the regular cycle timer.
2. Glass parts of the apparatus should be cleaned about once a month, at which time a routine inspection should be made.
3. Reliability of operation is assured by the traffic-timing mechanism incorporated into the apparatus.
4. Increased reliability with less frequent inspection will result with the use of the longer-life tubes now being made.

◆ ◆ ◆

Lackawanna Electrification Improves Suburban Service

Establishing a noteworthy precedent in the railroad world the Delaware Lackawanna and Western Railroad's recently completed suburban electrification places entire dependence upon 3,000-volt mercury arc rectifiers. Other features of design include the use of trolley voltage directly across car heaters, and general planning of all designs and equipment selections to permit extension of electrification throughout the system to serve overland freight and passenger trains.

By Edward L. Moreland
Fellow A. I. E. E.
Jackson & Moreland, Consulting Engineers, Boston

ELECTRIFICATION is enabling many steam railroads to solve problems of handling increasing amounts of suburban passenger traffic, where the bulk of such traffic comes in comparatively short morning and evening periods. The Delaware, Lackawanna and Western Railroad faced just such a problem in connection with its suburban lines in New Jersey when increasing demands made on these lines by New York traffic necessitated faster, cleaner, and more frequent train service. This was possible only through electrification.

In pursuing the present electrification program all designs and equipment selections were influenced by the ultimate possibility of complete electrification of the entire Lackawanna system, which includes both overland passenger and heavy freight service. A novel feature of the development is the use of 3,000-volt mercury arc rectifiers throughout for train supply. These devices have been proved to be lower in first cost and higher in operating efficiency at all loads than any other type of converting apparatus.

The present electrification covers approximately 68 route miles and 158 track miles of line in the suburban district west of Hoboken, N. J., and includes the main passenger line from Hoboken to Dover (via Newark, the Oranges, Summit and Morristown) and the branch lines to Montclair and Gladstone. It covers only local passenger service except for the electric transfer of freight trains between the freight classification yard at Secaucus and the terminal pier-head yard in Jersey City, adjoining the Hoboken terminal. In the passenger service multiple-unit cars are used exclusively, while for freight transfer service "three-power" locomotives are employed.

POWER SUPPLY AND SUBSTATIONS

Power for the electrification is purchased from the three power companies serving the territories in which the substations are located, and is delivered by the power companies to the five railroad substations in the form of three-phase, 60-cycle alternating current, at the voltages available on the power companies' systems in the vicinity. There is no transmission of a-c. power by the railroad along the rights-of-way used for traction purposes.

The locations of the substations are shown on the map (Fig. 1). Power is supplied at the West End and Roseville substations by the Public Service Electric and Gas Company at 13.2 kv. and 26.4 kv., respectively; at the Summit substation by the Jersey Central Power and Light Company at 66 kv.; and at the Bernardsville and Denville substations by the New Jersey Power

---

From "Lackawanna Suburban Electrification," (No. 31-18) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

and Light Company at 33 kv. The West End and Roseville substations are supplied by underground cable circuits and each of the other three substations by overhead lines.

Four of the substations—namely, West End, Roseville, Summit and Denville—are at junction points and an operator will be kept in attendance at all times. They, therefore, are not equipped with complete automatic control, although many of the functions are automatic. The Bernardsville substation is fully automatic with supervisory control from the Summit substation 13.4 mi. away.

Mercury arc rectifiers are used exclusively for converting from 60-cycle alternating current to the 3,000-volt direct current required for traction purposes.

A-C. Supply Circuits and Control. A typical substation showing the arrangement and connection of the rectifiers and associated apparatus is given in cross-section in Fig. 2. A-c. switching structures are of the outdoor type in all substations.

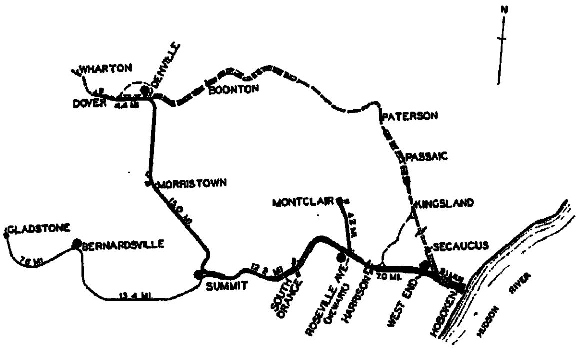


Fig. 1. Map of Lackawanna suburban lines east of Dover, N. J., showing electrified sections and substation locations

Connections from the a-c. bus to the rectifier transformers are through oil circuit breakers with instantaneous overload protection. The main transformers have three-phase delta-connected primaries, with ratio adjusters externally operated from the ground, and all twelve-phase zig-zig secondaries are provided with protection against overheating.

At the West End and Roseville substations the incoming a-c. power feeders are connected to the bus through oil circuit breakers and disconnecting switches. Both of these substations are equipped with four twelve-phase transformers each supplying power to a twelve-phase, 3,000-kw. rectifier tank.

At the Summit and Denville substations the incoming a-c. power feeders are connected to the bus through horn-gap air-break switches. In these cases the oil circuit breakers in the power companies' substations supplying the feeder circuits are relied upon to clear the associated circuit in the event of a fault on a section of the bus. If, however, conditions on the power companies" systems should change so that the present method of operation would no longer be satisfactory, provisions are made for later installation of oil circuit breakers instead of the horn-gap air-break switches. These two substations are each equipped with two twelve-phase transformers each supplying power to two six-phase, 1,500-kw. rectifier tanks. Normally, both rectifier tanks of each two-tank unit will be operated together; but in event of failure of one tank of a pair, the faulty tank can be disconnected by opening disconnecting switches provided in the leads to the anodes, and the other tank operated alone.

At the Bernardsville substation incoming a-c. power feeders are also connected to the bus through horn-gap air-break switches. Normally this station will be supplied from one circuit, the second circuit being used only in case of failure of power on the first circuit. At this substation there are two twelve-phase, 1,500-kv-a. transformers, each supplying power to a twelve-phase rectifier tank.

In all stations, lightning protection to the a-c, bus is provided by oxide film-type lightning arresters.

D-C. Bus Arrangement and Circuit Control. On the d-c. side of each substation, main and auxiliary buses are provided, each bus being sectionalized by a disconnecting switch, but operated normally with the secionalizing switch closed. The d-c. feeders connecting the substation bus to the catenary system are controlled by high-speed circuit breakers of the magnetic blow-out type, with holding coils energized from a storage battery.

In all stations, a lightning arrester of the electrolytic aluminum cell type, with balancing resistor and shunted spark-gap, is provided on each d-c. feeder and on the d-c. main bus.

Bernardsville Automatic Substation. As previously mentioned, four of the five substations are manually operated. The fifth, Bernardsville, is fully automatic with supervisory control from the Summit substation. Normally power will be supplied to this substation over a single circuit, but provision is made for automatically throwing over to a second circuit in the event of failure of power on the first. Once having changed over to the second circuit, the system does not automatically change back to the first circuit on restoration of power on that circuit unless there is a failure of power on the second circuit.

The automatic features provide also that either of the two rectifier units may be made the preferred unit, and that the second unit will come automatically into service when the load on the first exceeds a predetermined amount; this second will then drop out automatically after a predetermined time delay when the total substation load drops below a certain amount. The preferred rectifier may be kept on the line continuously or the control may be further adjusted to bring it on only when there is a load demand on the substation, and to take it off the line after a definite time delay when the load has decreased below a predetermined amount. In the event of a fault on either rectifier or any of its auxiliary circuits, that rectifier is automatically locked off the line. If the fault is on the preferred rectifier, the second rectifier will take its place automatically.

Signal and Auxiliary Power Supply. In addition to the 3,000-volt direct current supplied from the substations for traction purposes, each of the substations furnishes 2,300-volt, single-phase, 60-cycle power for signal operation. The West End, Roseville and Denville substations also supply 6,600-volt, three-phase, 60-cycle power for railroad auxiliaries, station lighting, and miscellaneous power requirements along the right of way.

Rectifiers. Rectifiers rather than motor-generators were selected for the conversion of the 60-cycle a-c. power to 3,000-volt d-c. power because of their relatively low first cost, high efficiency, ability to carry heavy overloads without injury, and the economy of substation design resulting from the small space occupied and the absence of heavy foundations required for motor-generators. Fig. 3 shows the comparative efficiencies of 3000-volt mercury arc rectifier sets and motor-generator sets of similar capacities.

These rectifiers were bought under a specification requiring guarantee of successful operation in service under loads of 150 per cent of current rating (50 per cent overload) for two hours and 300 per cent of current rating (200 per cent overload) for five minutes.

The rectifier tanks are equipped with the usual arc-striking anodes, holding (or exciting) anodes, vacuum pumps, and gages. The tanks are water-cooled, using a closed cooling system with forced circulation under thermostat control. The circulating water for each rectifier tank is re-cooled in a cooler unit associated with that tank somewhat similar to an enlarged automobile radiator using a circulating pump and motor-driven fan. Heating elements under thermostat control are also provided to prevent various parts of the rectifiers becoming too cool when shut down or lightly loaded.

D-c. smoothing reactors to reduce the ripple in the d-c. voltage, and resonant shunts to drain off high-frequency harmonics which would cause interference on communication circuits, are also provided. Surge suppressors made up of capacitors with limiting resistors are provided to protect the transformer secondary windings and the interphase transformer windings against high-voltage surges.

The shell of the rectifier tank and some of the associated equipment is at substantially cathode potential (3,000 volts above ground) when the rectifier is in operation. This equipment is therefore insulated from ground and carefully protected from accidental contact while in operation.

Fig. 4 is an interior view of a substation, showing the arrangement of the rectifiers and enclosing grilles.

In addition to the overload protection provided by the oil circuit breaker on the a-c. side of the transformer, each rectifier unit is protected by a high-speed circuit breaker of the magnetic blow-out type on the positive side (cathode connection) and by a similar high-speed circuit breaker short-circuiting a load-limiting resistor on the negative side (connection to mid-point of the interphase transformer).

Rectifier Grid Excitation. Aside from the voltage and capacity of the units, the outstanding features of the Lackawanna rectifiers are the anode grid excitation and the automatic compounding. In addition to the usual provisions for shielding the anode from the mercury thrown up from the cathode mercury pool by the arc stream, each anode is also surrounded by an inner shield suspended from a porcelain insulator. This shield supports a mesh grid made of special high-melting-point metal and mounted just below the face of the anode; it is insulated both from the anode and the tank case. Voltage applied to the grid ionizes the mercury vapor near the face of the anode and thus assists in establishing the power arc.

Rectifier Compounding. The rectifier compounding circuit is shown diagrammatically in Fig. 5. The main power circuits are indicated by the heavy lines and the auxiliary compounding circuits by the lighter lines. As shown on the diagram the twelve-phase

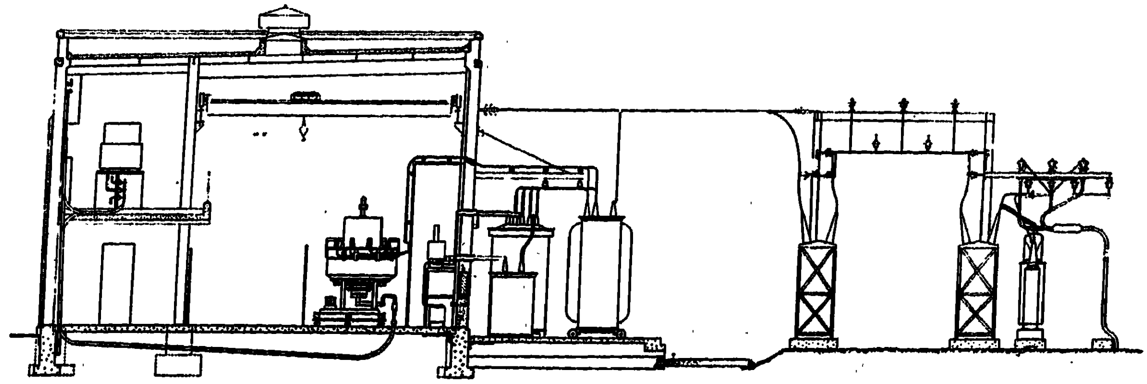


Fig. 2. Transverse sectional elevation of a typical Lackawanna substation showing equipment arrangement

secondary of the main transformer is made up of four three-phase secondaries with their neutrals connected together through interphase transformers.

The compounding is accomplished by shunting the third-harmonic interphase transformers (which connect neutral N^1 with N^2 and N^3 with N^4) by means of two tuned compounding circuits, each containing a capacitor and one winding of a compounding reactor. At very light loads the d-c. voltage corresponds substantially to the voltage of a three-phase rectifier; as load comes on, due to the shunting of the third-harmonic current from the interphase transformer winding through the compounding circuit, the condition approaches more and more nearly that of the six-phase rectifier, which gives approximately 15 per cent higher d-c. voltage with the same a-c. secondary coil voltage. The characteristic curve of one of the Lackawanna rectifiers when running compounded as determined by test, is shown in (a) of Fig. 6. For comparison the characteristic (b) when running non-compounded is also shown.

The power factor of the compounded rectifier unit including the transformer is notably high, showing approximately 96½ per cent lagging at 25 per cent load and increasing with load to 99 per cent lagging at 50 per cent load; at 150 per cent load it leads slightly but drops back to 99 per cent lagging at 300 per cent load. Due to the fact that they are connected in circuits carrying third-harmonic frequency the effect of the compounding capacitors on the power factor is greatly increased.

When compounded rectifiers are run in parallel it is necessary to provide an equalizer bus connected above the compounding reactor as indicated in Figs. 2 and 5, in order to assure equal compounding effect and equal division of the load between parallel units.

MULTIPLE-UNIT CAR EQUIPMENT

The multiple-unit car equipment in the initial electrification consists of 141 two-car units, each unit consisting of one motor car and one trailer car semi-permanently coupled together, with a control position and motorman's cab at each end of each two-car unit.

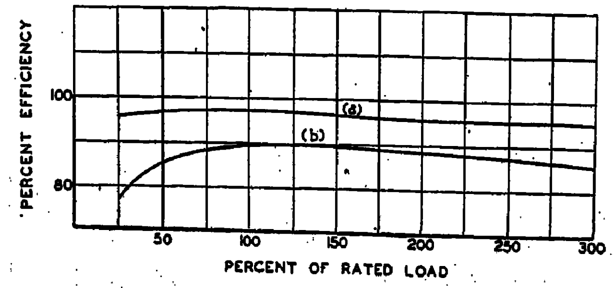


Fig. 3. Comparative efficiencies (including transformers) of (a) D. L. & W. 3,000-volt, 3,000-kw. mercury arc rectifiers and (b) 3,000-kw. motor-generators considered for use in the electrification

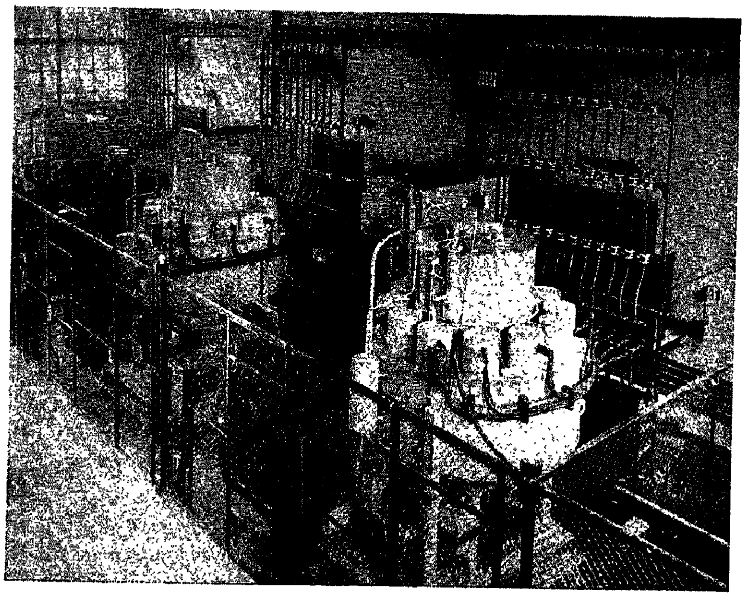


Fig. 4. Typical rectifier installation

Trains of from two to twelve cars are made up by coupling units together, the train control circuits connecting from unit to unit (and from car to car within the unit) by means of jumpers with plug connectors.

All motor cars are new steel cars, 70 ft. 3¼ in. long over bumpers, seating 84 passengers, and weigh, completely equipped, approximately 147,000 lb. without passengers. All trailer cars are remodeled steel cars formerly used in steam service. They seat 78 or 82 passengers, depending upon the type (except combination baggage and passenger cars and club cars, which seat less), are approximately 70 ft. long, over bumpers, and fully equipped weigh from 105,000 to 110,000 lb., exclusive of passenger load. Fig. 7 shows a view of an eight-car train made up of four of the two-car units. An extra express car (not electrified) is hauled on certain trains during non-rush hours.

Motor Equipment. Each motor car is equipped with four motors of 235 hp. (one-hour rating) each, the capacity of the motors being fixed by the requirements of local service with frequent accelerations. The motors are operated with series-parallel connections starting with four motors in series and cutting over to two parallel groups of two in series as the train comes up to speed. All motors, however, are insulated for the full 3,000 volts.

The motors are self-ventilated, using a series pull-push system. The cooling air is taken in through louvers at the top of the car, passes through settling chambers over the vestibules, then down through ducts built into the sides of the car and under the car, then through flexible "pants-leg" ducts to the motors. The air enters the motor at the commutator end through an end-housing connection admitting the air to the armature inside the commutator bell. It is sucked through the armature by the fan on the pinion end of the motor and forced back through the field windings to a discharge port at the commutator end of the housing.

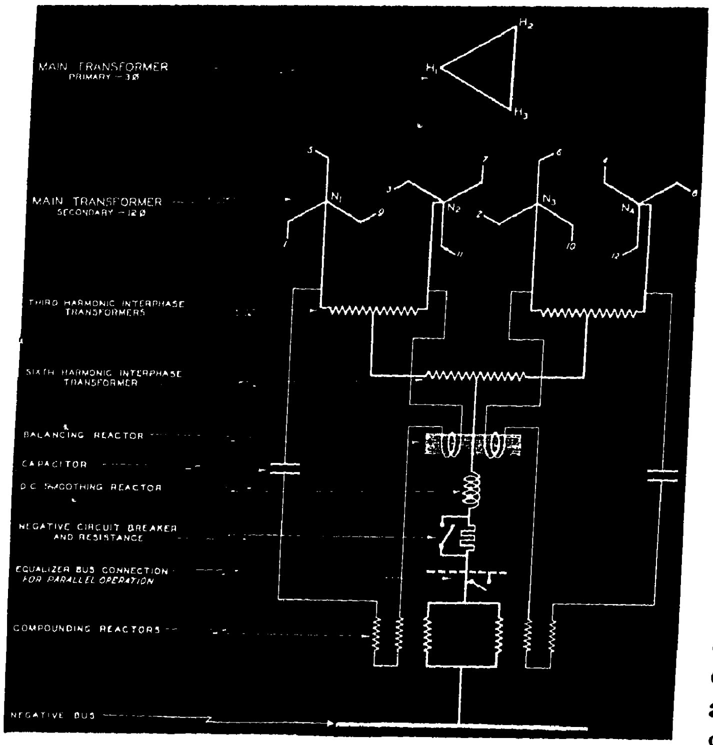

MAIN TRANSFORMER PRIMARY – 3Ø
H_1
H_2
H_3
MAIN TRANSFORMER SECONDARY – 12Ø
N_1
N_2
N_3
N_4
1
2
3
4
5
6
7
8
9
10
11
12
THIRD HARMONIC INTERPHASE TRANSFORMERS
SIXTH HARMONIC INTERPHASE TRANSFORMER
BALANCING REACTOR
CAPACITOR
D C SMOOTHING REACTOR
NEGATIVE CIRCUIT BREAKER AND RESISTANCE
EQUALIZER BUS CONNECTION FOR PARALLEL OPERATION
COMPOUNDING REACTORS
NEGATIVE BUS

Fig. 5. Simplified diagram of rectifier compounding circuit

Results indicate that this design is effective in keeping the motor free from dirt and snow without the necessity for filtering the air.

Control and Auxiliary Equipment. Each motor car is equipped with two pantographs, only one of which will normally be used at a time. The pantographs have four self-alining roller bearings, are spring-raised and air-lowered, and have a working range of from 15 ft. 6 in. to 25 ft. 3 in. above top of the rail. The standard pantograph has two contact shoes each equipped with two wearing strips with a grease groove between. For comparative purposes, however, 50 pantographs have been provided with single-contact shoes, each with two wearing strips and a grease groove.

The control system operates at 32 volts supplied by a storage battery carried on the motor car. This battery also supplies power for lighting both the motor car and its associated trailer car. A master controller is located in each end of each two-car unit. This control equipment provides for automatic train acceleration of 1.5 mi. per hr. per sec. The balancing speed of a six-car train is approximately 65 mi. per hr.

A dynamotor (with two windings in series) mounted under each motor car provides 1500-volt power for operation of a 1500-volt air compressor, and also drives by direct-shaft connection, a 4-kw. battery-charging generator for charging the control and lighting battery. The dynamotor is self-ventilating, taking its ventilating air directly from beneath the car through a centrifugal air separator.

The air compressor has a displacement of 36 cu. ft. per min., and in the event of failure of one compressor of a two-unit train, is adequate to supply the total requirements of a four-car train with an ample margin of reserve.

Push-button control switches mounted in the operator's cabs provide for controlling the pantographs, the control circuit, the heater circuit, the main-line breaker, the dynamotor, the number and gage lights, and the headlights.

Heaters. Heating on all cars is supplied by totally enclosed resistance-type heaters operated under thermostat control and connected in series on 3000-volt circuits. The wiring for these heaters is shown in Fig. 8 which is a schematic diagram of the entire car circuit. On the standard passenger cars the heaters are mounted under the seats with 40 heating elements in series. The heating elements which are themselves totally enclosed and insulated are supported on porcelain block insulators mounted in steel cases, so designed as to guard fully against the possibility of coming in contact with the heating element. The heater cases and the conduits leading to them are thoroughly grounded. The heater circuit in the trailer car is supplied from its associated motor car by a heater bus jumper on the roof of the cars. There is no 3,000-volt connection between separate units, each unit being entirely independent of the other units in the train except for the control circuits connected through by jumpers underneath the cars and for the air lines which are also connected through.

CAR CIRCUIT PROTECTION

All car circuits are protected by one main fuse of a new expulsion, compression type, mounted on the roof of the car, and connected directly to the pantographs. The motor circuit is further protected by a main line breaker consisting of four magnetic blow-out contactors in series and an overload relay. All auxiliary circuits are fed as a group through a limiting resistor of 1.5 ohms (which would limit a short-circuit current to a maximum of 2,000 amperes). Each auxiliary circuit is protected individually by an expulsion fuse, the dynamo circuit having in addition a permanent resistance of 13.5 ohms connected in series.

The main fuse has a continuous rating of 300 am-

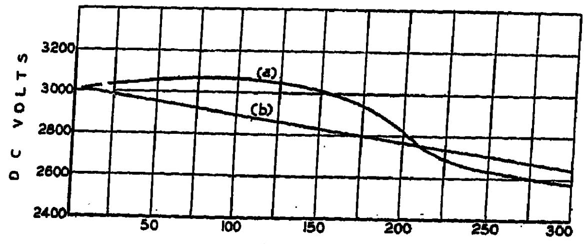


Fig. 6. Rectifier regulation characteristics showing voltage (a) compounded and (b) non-compounded

peres, or 650 amperes for 30 sec. The dynamotor circuit and heater jumper circuit to the trail car are each fused for 20 amperes, and the heater circuits for 8 amperes each.

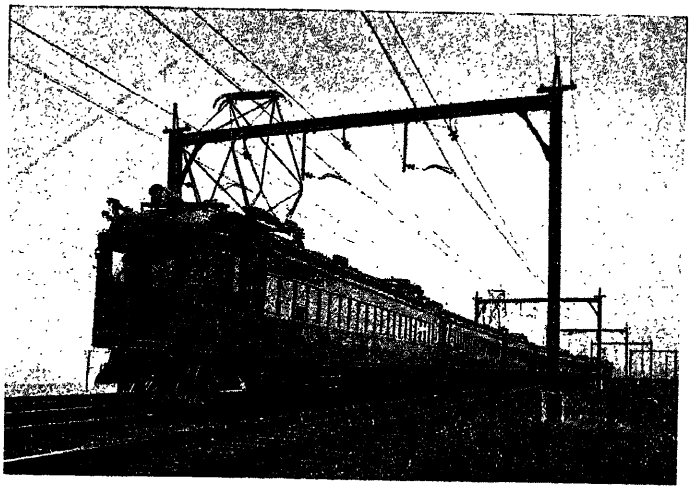


Fig. 7. Lackawanna suburban train made up of two-car units. Typical overhead construction for curved track also may be seen

Lightning protection is provided on each motor car by an electrolytic aluminum cell lightning arrester with balancing resistor and shunted spark-gap.

LOCOMOTIVES

Two locomotives of the three-power type shown in Fig. 9 have been provided for handling the freight transfer service between the Secaucus and the Jersey City yards, a distance of approximately four miles. When on electrified tracks, these locomotives operate from the 3,000-volt contact system, and when on non-electrified tracks, on internal power provided by a 300-hp. Diesel engine direct-connected to a 200-kw., 750-volt generator supplemented by a storage battery of 360 cells with a rating of 242 kw-hr. (340 ampere-hours). Each locomotive weighs 248,000 lb. with all the weight on four driving axles, is equipped with four motors of 400 hp. (one-hour rating) each and has a tractive effort of 60,000 lb. Each locomotive is capable of hauling a train of 2,500 tons, trailing load, at a balancing speed of approximately 28 mi. per hr. when operating on external power from the 3,000-volt contact system, or at approximately 12½ mi. per hr. when operating on internal power only. When running light on internal power the locomotive has a balancing speed of approximately 30 mi. per hr.

DISTRIBUTION SYSTEM

With two minor exceptions the 3000-volt power for operation of the trains is distributed through the contact system only, without the use of auxiliary positive feeders.

The catenary system is of the tangent-chord type. On main-line tracks it consists of a composite main messenger, an auxiliary messenger and two contact wires. The main messenger has a breaking strength of 31,000 lb. and an equivalent conductivity of 350,000-cm. hard-drawn copper. The auxiliary messenger is 2/0 hard-drawn copper and the contact wires are two 4/0, grooved bronze wires of 55 per cent conductivity. The total equivalent conductivity of the standard main line catenary system is 720,000-cm. hard-drawn copper per track. On yard tracks and cross-overs a lighter system is used with a 7/16-in. bronze messenger and a single 4/0, 55 per cent conductivity bronze contact wire.

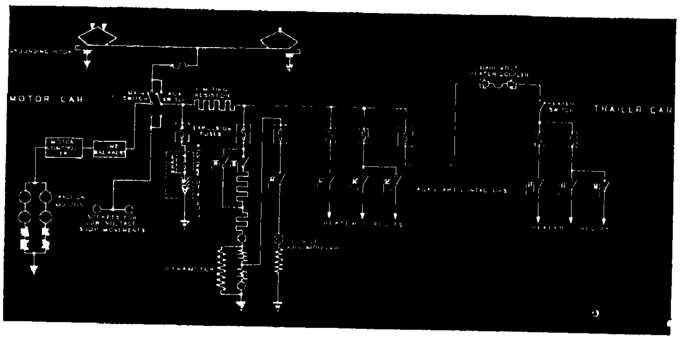


Fig. 8. Simplified diagram of car wiring; note heating circuits connected directly to 3,000-volt trolley circuit

Catenary Supports. Steel catenary supporting structures are used throughout except on the branch line from Summit to Gladstone, which is a single track line on which wood poles with steel brackets are used except at special locations where steel structures are required. The standard steel supporting structure has H-columns and either an H-beam or a latticed truss cross member, the H-beam being used up to spans of 53 ft. and lattice truss for longer spans. On tangent track the standard spacing between catenary supports is 300 ft. In general the signals and catenary system are supported on the same structures which support the catenary, as illustrated in Fig. 10.

Tie Stations and Catenary Sectionalizing. Except on the single track branch line from Summit to Gladstone, tie stations (or circuit breaker sectionalizing stations) are located approximately midway between substations, and also at or near the ends of stub-end lines. The locations of the tie stations and the distances between substations are shown on the map, Fig. 1, already referred to. At the tie stations the catenary system is sectionalized and all circuits are brought to a common bus through high-speed circuit breakers, the holding coils of which are energized from the line. With this arrangement advantage is taken of multiple feed with reduced copper losses between substations and tie stations without sacrificing selective protection of the line. All tie stations are largely automatic in function but are also under remote or supervisory control from the nearest railroad signal tower. The high-speed circuit breakers connected with circuits which are also fed at the other end from a substation are arranged so that after opening under a line short circuit or overload, they reclose automatically as soon as voltage is restored on the circuit (*i. e.*, when the circuit has been energized from the substation end by the operator at the substation, reclosing the feeder breaker). On stub-end lines which receive power at one end only, the breakers, after opening under short circuit or overload, automatically reclose three times at definite intervals and then lock out if the fault has not been cleared.

The trip points of the high-speed magnetic blow-out circuit breakers are adjustable as to current and also as to sensitivity to the rate-of-rise of the current. New features of these breakers permit increased flexibility in the rate-of-rise adjustment. Means are also provided for calibrating the breakers with low-voltage battery current (maximum, 20 amperes at 12 volts).

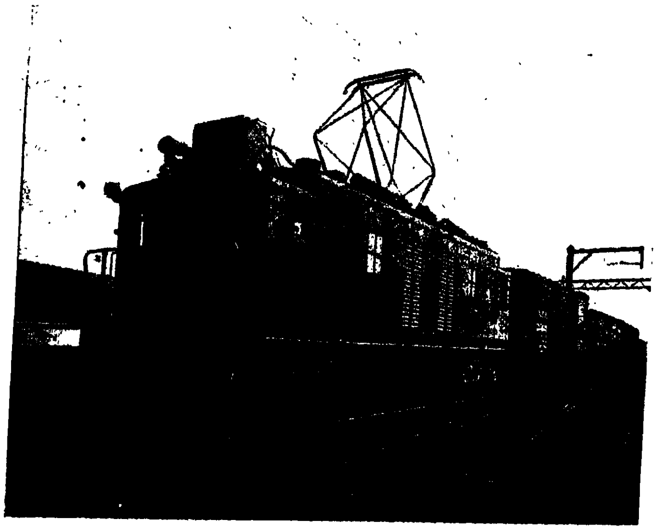


Fig. 9. Combination trolley-Diesel-battery locomotives used for freight transfer

Other Features

In connection with the electrification program a complete change in the signal system became necessary. The signals and track circuits were formerly battery-operated and the signals throughout most of the territory electrified were of the old semaphore type. All signals in the electrified zone have now been changed to colored light signals with a-c. track circuits. Impedance bonds are provided in the tracks at all signal locations. At all other points the standard track bonding consists of a single 4/0, 8½-in., gas-welded, stranded-copper, steel-terminal, U-bond at each joint on each rail.

Extensive surveys and tests were made both before and after electric operation of trains was begun to determine the points at which there might be danger of electrolytic damage to underground cable sheaths and other metallic structures, and drainage cables have been installed where they were found desirable.

Where necessary to provide adequate physical clearance, communication circuits located along the right-of-way, consisting of the railroad's communication lines and some other telephone and telegraph lines, have been moved or put into cables. Inductive interference from the d-c. power flowing through the catenary system has been practically eliminated by the use of twelve-phase rectifier transformers, d-c. smoothing reactors and resonant shunts, installed at the substations.

The mercury arc rectifiers also cause a distortion of the wave form on the a-c. supply circuits, and where the a-c. power is supplied by overhead transmission lines inductive interference in neighboring telephone circuits may be experienced unless steps are taken to guard against it. This effect can, however, be largely eliminated by proper coordination and transposing of the power circuits and the neighboring telephone circuits. This has been taken care of by the cooperative effort of the power companies and the telephone companies. No radio interference has been reported.

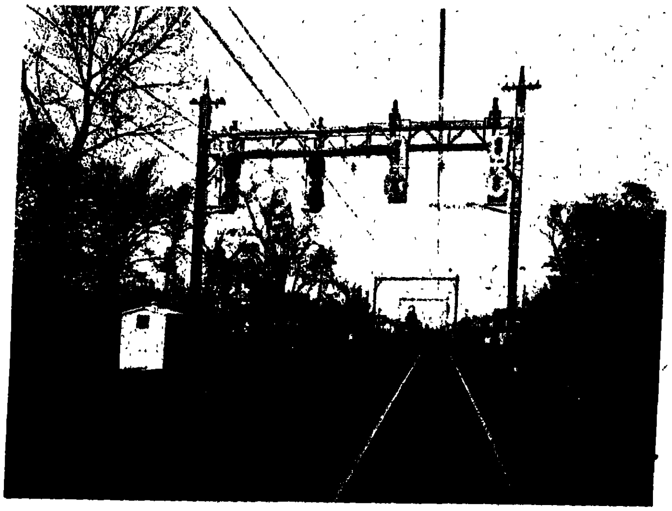


Fig. 10. Typical overhead construction on a three-track tangent section

This is the first electrification program attempted in this country in which the entire power supply for tractive purposes depends solely on the satisfactory performance of mercury arc rectifiers. Such a project would have been impossible of completion in this way had it not been for vast improvements in the design of these devices which enable them to be built for higher voltages and heavier loads than heretofore. These advances have been made possible by the intensive research and development work which has been applied to converting apparatus in general during the past few years. The installation of such a system constitutes a bold step forward in the electrification field, and its effect on future projects of this sort will be watched with keen interest.

◆ ◆ ◆

Your Nimble Servant —the Electron

A summary of the present scientific understanding of electronic theory presented briefly in non-technical language.

By Karl Taylor Compton

President, Massachusetts Institute of Technology
Cambridge, Massachusetts

THE ELECTRON, as is commonly known, constitutes the smallest known division of matter. Science has shown it to be a peculiar combination of mass (minute though it is) and electrical charge, and that its inherent characteristics exhibit a singular combination of rotation and wave motion. All electrical phenomena are directly dependent upon the workings of countless numbers of these infinitesimal particles. A stream of them flowing along a wire constitutes a flow of electric current; millions of them boiling off hot metal filaments give us modern radio and the talkies; still more millions of them are active in our luminescent electric signs, while television is providing still another job for these "nimble servants."

In 1899 experiments on the striking luminous and electrical effects accompanying the discharge of electricity through vessels containing gases at reduced pressure led to the discovery that in these phenomena, the primary agent which we now know as the electron is a negatively electrified particle 1,846 times lighter than the lightest entity then known, the hydrogen atom, and bears an electric charge which is a natural indivisible unit of electricity. Electrons are affected in various ways by a wide variety of agencies, such as heat, light, chemical action, and shock. In some cases they are ejected from bodies spontaneously; in other cases they are pulled out by intense electrical fields. Spontaneous emission of electrons is one of the three phenomena shown by radioactive substances, and it occurs in the process of actual transmutation of one chemical element spontaneously to another.

These properties of the electron were discovered by Sir J. J. Thomson and his pupils immediately following the year 1899. About 12 years later Millikan and his pupils made much more accurate measurements of the magnitude of the electric charge on an electron. As a result of this work it may be said truly that although no one ever has seen or ever will see an electron, and although it is the smallest charge and has by far the smallest mass of anything which is known, nevertheless its mass and its charge have been measured experimentally with an accuracy far beyond that with which materials ordinarily are weighed or measured.

MAGNETIC PROPERTIES

Light produced by the motions of electrons in atoms has been found to be affected in a peculiar way by the presence of a magnet. By means of a magnetic field the light which may be given out at a certain definite wavelength and appear as a certain definite color or line in the spectrum may be split up into several components, some of longer and some of shorter wavelength, and having peculiar properties of polarization. This effect is so small that it can be observed only under the influence of powerful magnetic fields; and even then it is so small that it must be examined with a magnifying glass. This phenomenon is known as the "Zeeman effect." It has led to the proof that an electron, besides being an electric charge, also is a tiny magnet of perfectly definite strength, and that therefore the electron may be oriented one way or another by the application of a magnetic field.

Magnetic effects are produced, of course, by electric currents and any circuit in which an electric current is flowing behaves like a magnet. This suggests that every electron is really a tiny electric circuit; or, in other words, that it consists of a rotating or revolving electric charge the revolution of which is equivalent to a current in an electric circuit. This suggests that the

---

From an address delivered at a special session of the A. I. E. E. winter convention, New York, Jan. 28, 1931.

electron is a spinning electric charge, and therefore that in addition to having mass and electric charge, it has a definite magnetic moment and an angular momentum.

WAVE PROPERTIES

The electron also has the properties of a wave. The phenomenon of interference is widely known as characteristic of all types of wave motion, including light, heat, ripples, elastic vibrations, radio waves, and similar phenomena; but G. P. Thomson, son of Sir J. J. Thomson, was the first to show that when electrons pass through tiny apertures, there are phenomena of interference exactly similar to the phenomena of interference occurring when light passes through similar small apertures. This is perhaps the most striking demonstration of the fact that an electron has the properties of a wave. The same conclusion had been reached by a different interference phenomena a short time earlier by Dr. Davisson and Dr. Germer of the Bell Laboratories.

This wave nature of the electron is of a peculiar kind, in that the wave appears to be associated with it, directing it in its motion. There is a sort of indeterminism in the motion of any individual electron, but the probability or statistical likelihood of definite direction of motion can be determined from the properties of the wave which is associated with it. The wave furthermore has the peculiar property of a wavelength varying inversely as the momentum of the electron.

CURRENT FLOW EXPLAINED

Long before the existence of electrons was suspected it was found that the amount of current flowing in any given metallic circuit was exactly proportional to the voltage. This is the relationship as stated in the familiar Ohm's law. From the scientific standpoint it has been of great interest and until recently, a great puzzle as to just what determined this proportionality between current and voltage. According to the presently accepted ideas the more loosely bound electrons in the atoms which make up the metal are, under the influence of neighboring atoms, detached from their original parent atoms and are free to move somewhat at random throughout the metal. This motion is governed in part by temperature, since, on the average, the higher the temperature the more rapidly these electrons will move. The motions of the electrons are not all alike in velocity or direction, but are distributed at random according to a certain law of probability given by what is known as the Fermi statistics. These electrons are interfered with in their motion in various directions by collisions with each other or with atoms. When a voltage is applied, however, there is a constant force impelling them on the average to drift in the direction of the voltage, and it is this drift which constitutes the electric current.

In the earlier theories, the collisions just referred to were conceived of as if with atoms which behaved like hard, resilient spheres; but this was obviously too crude an approximation to fit the facts; an apparently satisfactory picture is the recent one credited to Sommerfield and his pupils, according to which the motions of electrons in metal are governed by the interference of their waves in passing through the lattice-like structure of the atoms. According to this idea the deflection of an electron at collision means simply that the electron wave has been bent or diffracted out of its original path.

All this has brought about a very close analogy between some problems in electrical conduction and some problems in the propagation of light; and underlying this whole subject is a new branch of mechanics called "quantum mechanics." According to quantum theory, mechanical or electrical phenomena involving particles of electronic or atomic dimensions have to be treated by "wave mechanics," whereas phenomena occurring between larger bodies of a tangible size are treated by the ordinary electrodynamical methods; in other words, ordinary electromechanical concepts represent the special form which the quantum mechanics takes when applied to large bodies.

ELECTRON MOTION IN GASES

Conduction of electricity through gases, which was the phenomenon that originally led to the discovery of the electron, still supplies perhaps the most complicated and intriguing problems in electricity. In such phenomena there must be considered the electron which is moving rapidly under the influence of the applied voltage and making frequent collisions with gas molecules; there must be considered also the heavy positive ions which result when electrons are knocked out of molecules, and which move relatively sluggishly in the opposite direction. Due to concentrations of one or the other kind of these electric charges in different parts of the gas, there is produced a very irregular distribution of the voltage through the gas, which accounts for some of the striking optical and electrical peculiarities of gas discharges.

Another peculiarity of electric currents in gases is that as the current increases, the resistance of the gas decreases. Because of this fact electric currents in circuits containing a path through a gas show many remarkable peculiarities, such as electric oscillations and discontinuous changes. Familiar forms of these phenomena include sparks, electric arcs, and the great variety of sign-lighting devices, such as neon tubes and mercury arcs. Lightning and aurora borealis are examples of such currents in cosmic phenomena.

Another interesting phenomenon is the thermionic emission of electrons. As already mentioned, the average speed of electrons in metals is controlled by the temperature of the metal, and if this temperature is raised sufficiently high an appreciable proportion of the electrons which strike the surface of the metal from the inside will be moving fast enough to escape entirely from the surface in spite of forces which tend to pull them back. It is these evaporated electrons which constitute the electric currents in radio tubes. There the hot filament is the source of electrons which are evaporated into the surrounding space and are drawn to the plate subject to the controlling action of the voltage impressed upon the intervening grid.

ELECTRONS RESPOND TO LIGHT

When light, particularly ultra-violet light, falls upon metals, electrons may be ejected from the metals. The stronger the light the more electrons are ejected; and the shorter the wavelength of the light the greater the velocity with which they emerge. This phenomenon was accidentally discovered nearly 50 years ago, although its exact nature was not then understood. One of the most important contributions which Einstein has made to science was brought out in 1905 in his application of the quantum theory to explain the relation between the wavelength of the light and the velocity of ejection of the electron.

At the present time these so-called photoelectric currents are perhaps the most sensitive means in existence for the detection of light. They are used in stellar photometry and are the heart and soul, so to speak, of all television apparatus. This photoelectric phenomenon, too, is capable of a great variety of applications. For example, it permits electrical registration to be made of visitors entering a door; it permits automatic sorting of cigars, fruit, cloth, or other objects according to color; it enables the U. S. weather bureau to make a continuous electrical record of the brightness of sunlight; it performs innumerable important laboratory functions.

THE ELECTRON IN CHEMISTRY

A most interesting series of lectures was delivered at the Franklin Institute in Philadelphia a few years ago by Sir. J. J. Thomson concerning the electron in chemistry. It has become evident now that the so-called "chemical forces" or valence forces which the chemist has used to account for the sticking together of atoms to form all the multitudinous varieties of molecules are nothing more or less than electric and magnetic forces existing between atoms and caused by the space distribution motion of electrons. Thus the whole field of chemistry on the interpretive side is turning into a study of electronic effects.

One of the most effective ways to investigate any object which cannot be seen or handled is to stir it up in some way and then try to observe and interpret what happens; this is exactly the process of research in modern atomic physics and interpretive chemistry. Atoms and molecules can be stirred up in a variety of ways—by heat or by electrical currents. Emission of light is the most frequently observed result of such agitation and from a spectrum study of that light it is possible to infer a great deal as to what went on in the atoms and molecules themselves. In principle this method has been the basis of all present knowledge of the structure of atoms and molecules and the fundamental electrical nature of matter.

Fundamental to, and inherent in, every aspect of mechanical and electrical properties of matter, there is the electron—always present and always active, and thus justifying perhaps the title of this article, "Your Nimble Servant, the Electron."

◆ ◆ ◆

Reducing Noises From Power Transformers

With a view to their reduction, objectionable noises have been under investigation in various parts of the country during the past few years. In line with such work, thoughtful attention is being given to the reduction of unnecessary noises in electrical machinery and apparatus. Causes of transform r noises have been determined and together with means suggested for control are described here.

By R. B. George
Member A. I. E. E.
Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

VIBRATION is the chief cause of the noises emanating from power transformers, since rotating parts, the most prevalent sources of noises in all machines, are completely absent. Electromagnetic pulsations set up by the alternations of the current in transformer windings give rise to mechanical vibrations. An impulse from each half-cycle of this current causes a fundamental frequency of vibration double that of the circuit in which the transformer is connected. Thus the

---

From "Power Transformer Noise, Its Characteristics and Reduction" (No. 30-178), presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

fundamental frequency of vibration in a 60-cycle transformer would be 120 cycles per second. These vibrations usually originate in the core-and-coil structure and are transmitted by the oil to the tank wall whence they are passed on into the outside air. Resulting sound emission is in the nature of a continuous hum of comparatively definite pitch and in most cases extremely annoying.

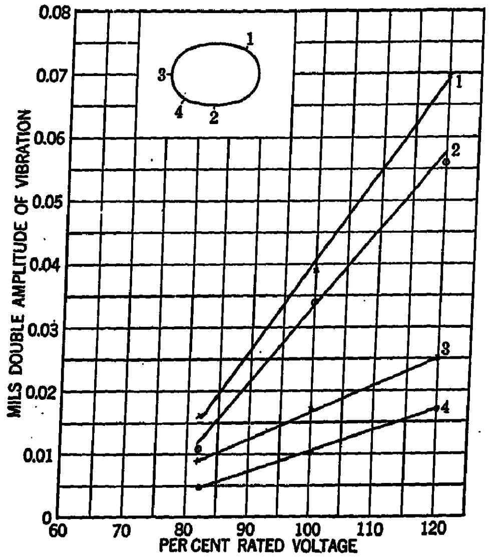


Fig. 1. Effect of voltage variation upon amplitude of transformer tank-surface vibration

Results of a theoretical investigation made to determine the different force components in transformers which might cause vibration show that:

1. The force between the winding and the core is an attractive force, but when solid insulation is wedged in between the coils and core, this force is not serious.
2. There is an attractive force which acts at each joint of the core and tends to make the iron circuit continuous; this force is directly proportional to the cross-section area and to the square of the magnetic density.
3. There are between parallel laminations of the core, forces of repulsion arising from like poles induced in adjacent ends of parallel laminations.
4. There are electrodynamic forces between the coils. These forces are attractive between coils of the same winding and repulsive between coils of different windings. They are proportional to the square of the ampere-turns per group.

In addition to the forces just enumerated, metal plates, tie rods, radiator tubes, structural steel parts, or other members, may be resonant and serve as unexpected sources of noise which are sometimes exceedingly troublesome. Power transformers having tanks with large areas exposed for radiating sound, however, usually have natural periods of vibration below 60 cycles.

To deal effectively with the noise problem, the sound analyzer developed by J. P. Foltz ("Study of Noises in Electrical Apparatus" TRANS. A. I. E. E., July 1929) was used in these investigations. The instrument consists principally of amplifiers and filter circuits which can be set to eliminate all but a certain frequency. The noise to be analyzed is picked up by a microphone and passed through the filter circuits. The setting of the filter-circuit condenser indicates the frequency of the sound measured, and a meter indicates in dynes per sq. cm. the intensity of the sound at that frequency.

For comparing sounds with reference standards, this analyzer is independent of the human ear and therefore leaves nothing to the personal judgment or imagination of an individual listening to a telephone receiver. When it is desired to measure mechanical vibration, a calibrated phonograph pick-up is substituted for the microphone; then the sound analyzer can be used to measure the frequency and amplitude of vibration.

Vibration amplitude and frequency measurements were made on the tank surfaces and core-and-coil parts of a number of representative sizes of completely assembled transformers at no-load and at different voltage values. These tests were to determine the effect of line voltage regulation on the amplitude of vibration and the corresponding sound intensity. Fig. 1 shows some of the results of tests on a large transformer at the elevation of the center of the core; locations of the points are indicated on the plan view at the upper left hand corner of the figure. These curves are approximately straight lines, indicating that the vibration component due to voltage regulation can be considered directly proportional to the per cent change in line voltage within the operating range of the transformer. The ratio varies with different designs but is usually of the order of 30 per cent change in sound intensity for 10 per cent change in primary voltage at no-load.

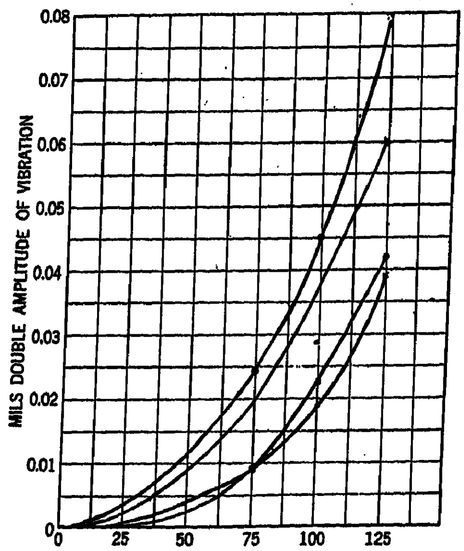


Fig. 2. Effect of load current upon amplitude of transformer tank-surface vibration

Tests were made also on the core-and-coil parts of transformers to determine the characteristics of those parts which act as sources of noise due to load currents in the windings. These tests were made with one transformer winding short-circuited and sufficient voltage impressed on the other winding to obtain the desired values of load current. Vibration amplitudes and frequency measurements were taken for each load. There were similar tests on completely assembled power transformers where surface vibration measurements were made also on the tank and other exterior surfaces. Results of tests on one of these transformers are shown in Fig. 2. Measurements were taken at four representative points at different elevations on the side of the transformer. It may be observed that the amplitude of vibration varies approximately as the square of the load current.

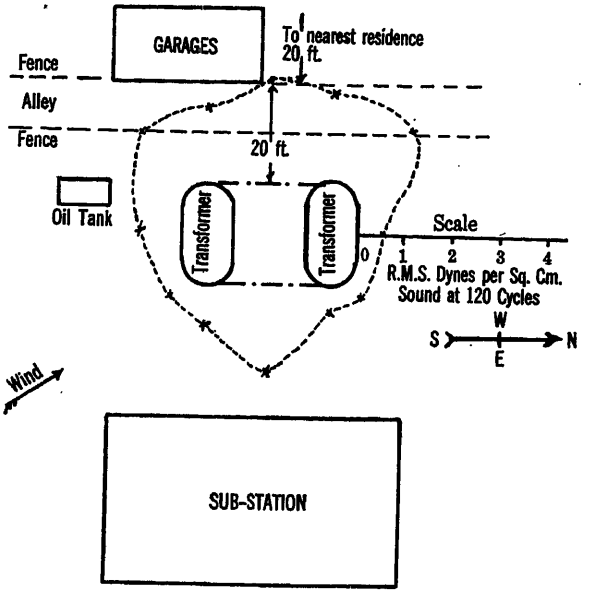


Fig. 3. Intensity distribution of 120-cycle sound measured at points 20 ft. from transformers. Reflections from nearby buildings and effect of wind may be noted

Results of frequency analyses at the points of maximum amplitude of vibration observed on the load and voltage tests showed that different harmonic frequencies were present under both sets of conditions. All of these harmonic frequencies were exact multiples of the 60-cycle power frequency. However, vibration amplitudes at frequencies above 120 cycles were usually so small as to be negligible. The test range included frequencies up to 3,000 double vibrations per second, but no vibrations were noted at frequencies above 600 cycles.

Another investigation was made to determine the distribution of sound at 120 cycles measured at a distance of 20 ft. from the transformers at the substation shown in Fig. 3. Since there are two transformers at this station, lines were drawn between them, and the resulting area treated as the noise source. The curve is plotted in modified polar form with reference to the tank wall and the two connecting lines described above. At a distance of 20 ft., the average vibration intensity was found to be 1.142 dynes per sq. cm., the minimum 0.48, and the maximum 2.06. This results in a maximum-to-minimum ratio of 4.3 to 1. Reflections from the substation building and the neighboring garages are evident, as is also the effect of wind, in the upper right hand corner of the figure. Both transformers were large three-phase units, carrying at the time of test about 84 per cent rated load at about 97 per cent rated voltage.

Fig. 4 gives another interesting illustration of the effects of the acoustic conditions at the substation; a smooth-finish, plastered wall was located diagonally as shown on the upper side of the figure and a hard wall of steel plates was located symmetrically on the opposite side of the transformer. The inner curve shows the distribution of vibration of the tank wall at 120 cycles; the outer curve shows the distribution of the intensity of sound at 120 cycles and at a distance of 42 in. from the tank wall. Both curves are plotted in modified polar form with reference to the tank wall. The average 120-cycle intensity was observed to be 0.385 dynes per sq. cm., the maximum 0.685, and the minimum 0.31, giving a maximum-to-minimum ratio of 2.2 to 1.

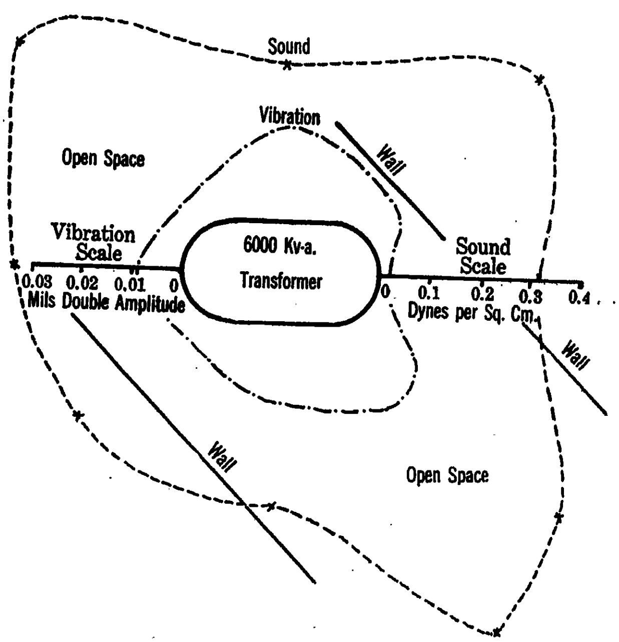


Fig. 4. Curves showing the effect which enclosing walls have upon the intensity distribution of 120-cycle sound from a transformer

Conclusions

These surveys mark an important advance in the knowledge of power transformer noise characteristics and magnitudes. The sound intensities are not uniform in all directions, the acoustic conditions at the substation playing an important part in the final distribution of sound.

The very nature of a transformer makes it always produce some hum, but for operation near hospitals or in residential districts this hum can be reduced by the following expedients:

(1) Using additional iron in the core in order to secure low magnetic density. This also means additional copper and a more expensive transformer.

(2) Stiffening the bracing and supporting parts to reduce vibration and in some cases adding damping devices to change the natural period of vibration.

(3) Adding cushions or padding between parts of the transformer.

(4) If sufficient area is used to prevent crushing, cork pads can be used under transformer tanks in indoor vaults. Arbors, hedges, shrubbery and trees are very effective for absorbing sound from outdoor substations.

◆ ◆ ◆

What of Surplus Power?

Surplus power, natural by-product of the electric service industry, should be developed and utilized in industrial processes under a definite program. A plan is proposed whereby the useful output of existing electric generating equipment may be increased as much as 30 per cent; improvement resulting in system load factor would permit economic construction of plants still more efficient, thus contributing constructively to the cycle.

By Farley G. Clark
Fellow A. I. E. E.

Consulting Engineer
Toronto, Ontario

MANY ATTEMPTS have been made to dispose of seasonal and off-peak power, but thus far the only reasonably successful scheme brought out is interconnection. This plan, however, reacts more toward the saving in reserve generating equipment than in the transfer of energy. The proposal for the utilization of surplus power as introduced in this article differs from others in that the rate of power supply is under the control of the power company, and as the total system load demands can be varied at will. Surplus power can be used in this way for a number of electrochemical and electrothermal processes and will result in markedly reduced costs for a great many commodities. For example, it is possible to manufacture illuminating gas at a cost that would compare favorably with the cost of natural gas at the end of a long pipe line.

For the purposes of this article, surplus or off-peak power will be defined as all power producible from the serviceable capacity of generating equipment that is not required to meet all other demands. The part of this surplus required for the proposed disposal is that portion which would result from the daily generation of a quantity of the surplus energy agreed upon as being available and usable.

Before the proposal has value, the utilities must agree that they have and long will continue to have this spare capacity available. They must assure themselves that the shape of the annual load-duration curves, which has not changed materially during 30 years except as to growth upward, is not likely to change its characteristic shape during the next 20 years. They must be assured that the day of maximum output, which is the main limitation, will continue to have the characteristic load curve which has been typical of the past 20 years of growth.

To avoid complications hydroelectric power is eliminated from consideration. Whenever kw-hr. can be stored in a reservoir the proposal is not attractive; but if steam reserves are needed, the situation becomes favorable.

POSSIBLE RATE REDUCTION

This surplus obviously is nothing but a potentiality; it is not demanded and it cannot be sold under existing terms and conditions; or if it is to be sold or profitably used, the terms must be modified to meet the new conditions. In fairness to the utilities, however, it will be necessary to state that never before have they been called upon to deal with the matter in any like manner or under the conditions proposed in this discussion.

If assumed premises are right and the conclusions are in accordance with the facts, the price of this surplus energy can be made sufficiently low to attract the attention of many possible users most of whom cannot avail themselves of it without becoming purchasers of quantities of the regular high-priced product. The proposal holds out no hope for an early reduction in standard rate schedules, a general reduction of which will come when the use of this surplus has so increased the capacity-use of equipment that more efficient and cheaper generating plants can be built.

During the early stages of development, it is essential that every cost advantage maturing in favor of the surplus generation should be accredited to it. For example, assume that a purchaser of surplus energy asks for 192,000 kw-hr. per day on a 20-year contract, and will allow the utility to vary at will the rate of delivery between 0 and 10,000 kw. Nine out of ten utilities having a maximum yearly peak of 100,000 kw. or more can meet this requirement and establish a new increment fuel rate about 5 per cent lower than their normal rate.

Some advantages of this plan are:

1. It would be unnecessary to operate or maintain reserves within the capacity of the superimposed load. It is obvious, therefore, that no part of the generating plant capital is involved in the supply of this surplus energy.
2. A regulable means would be provided for setting the total station load nearer to the point of greatest economy.
3. A means would result for absorbing the fluctuations of the normal load.
4. The load factor of the system would be increased.

The actual cost of this energy, when, as, and if generated, is the total production cost for any given period less the estimated cost during the same period for the other or normal load. There may be some difficulty in devising an accounting system to satisfy public service commissions, although it is expected to indicate costs which will provide sufficient latitude for the satisfaction of all concerned.

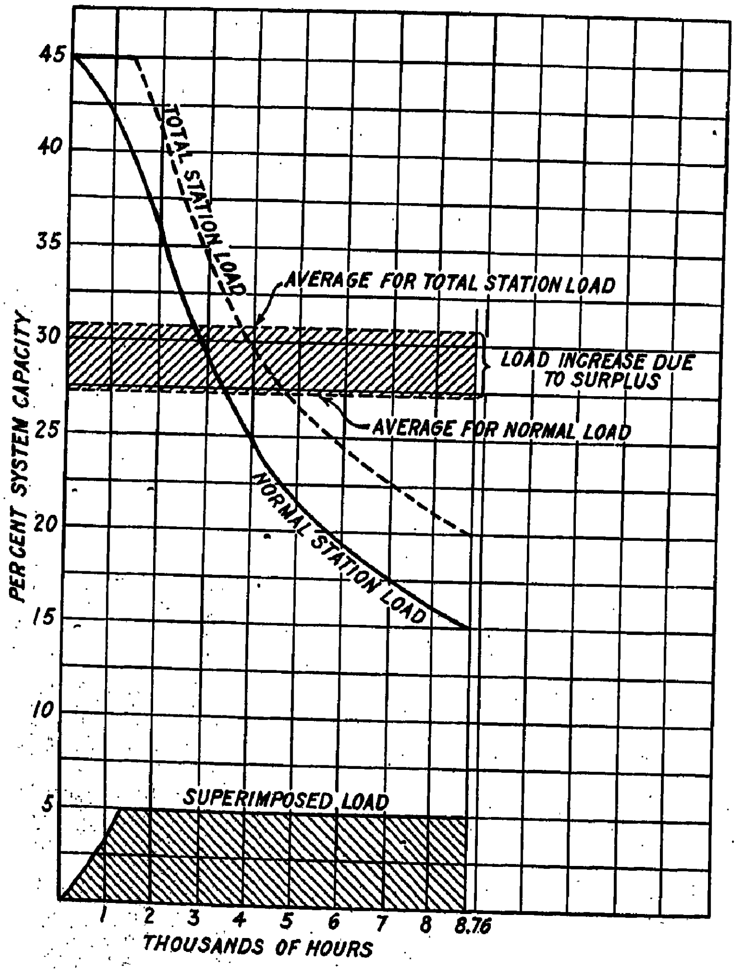


Fig. 1. Cumulative annual curves showing method of superimposing "surplus" load upon normal station load without increasing station demand

Surplus Power Now Available

Magnitude of the proposal can best be appreciated by calling attention to a few statistics for 1930 and estimates for 1940 with the trend discounted by reason of the existing depression.

According to statistics, there was installed in 1930 in the United States, a total steam-electric generating capacity of approximately 30,000,000 kw. in stations having a yearly output of about 60,000,000,000 kw-hr. During the period from 1900 to 1930 the maximum-load demand has increased seven times and the annual power output eleven times. On the basis of these facts it seems reasonable to predict a total installed steam-electric generating capacity of at least 45,000,000 kw. by 1940, and an annual power output of 100,000,000,000 kw-hr.

According to the calculations upon which this proposal is based, surplus power could be produced profitably on the basis of an annual output of at least 30 per cent of the present annual output; this means an output of 18,000,000,000 kw-hr. based upon 1930 statistics, and 30,000,000,000 kw-hr. based upon 1940 predictions.

Table I gives data for a suggested annual distribution of load by which this 30 per cent of surplus power can be furnished. Resulting improvement in load factor also is shown. It may be noted that according to this set-up the power is made available for 8,540 hr. out of a total of 8,760 hr. in the 365 days of a year. This arrangement provides for shutting down the surplus power supply during very high peak loads so that the maximum demand on the system is not increased.

TABLE I—SUGGESTED DISTRIBUTION OF LOAD FOR FURNISHING 30 PER CENT SURPLUS POWER OUTPUT

	1930		1940	
	Annual Service hours	Surplus power output in kw.	Annual service hours	Surplus power output in kw.
1st 5 per cent	8,540	360,000	8,540	600,820
2nd 5 per cent	8,322	380,500	8,322	634,200
3rd 5 per cent	8,059	403,000	8,059	671,500
4th 5 per cent	7,708	428,000	7,708	713,340
5th 5 per cent	7,271	457,200	7,271	761,040
6th 5 per cent	6,745	463,200	6,745	815,390
Normal load factor	0.225		0.254	
Load factor with 30 per cent surplus power	0.263		0.329	

In Fig. 1 is shown how this surplus load would be superposed on the normal system load for a typical power system. Fig. 2 shows how the load might be distributed

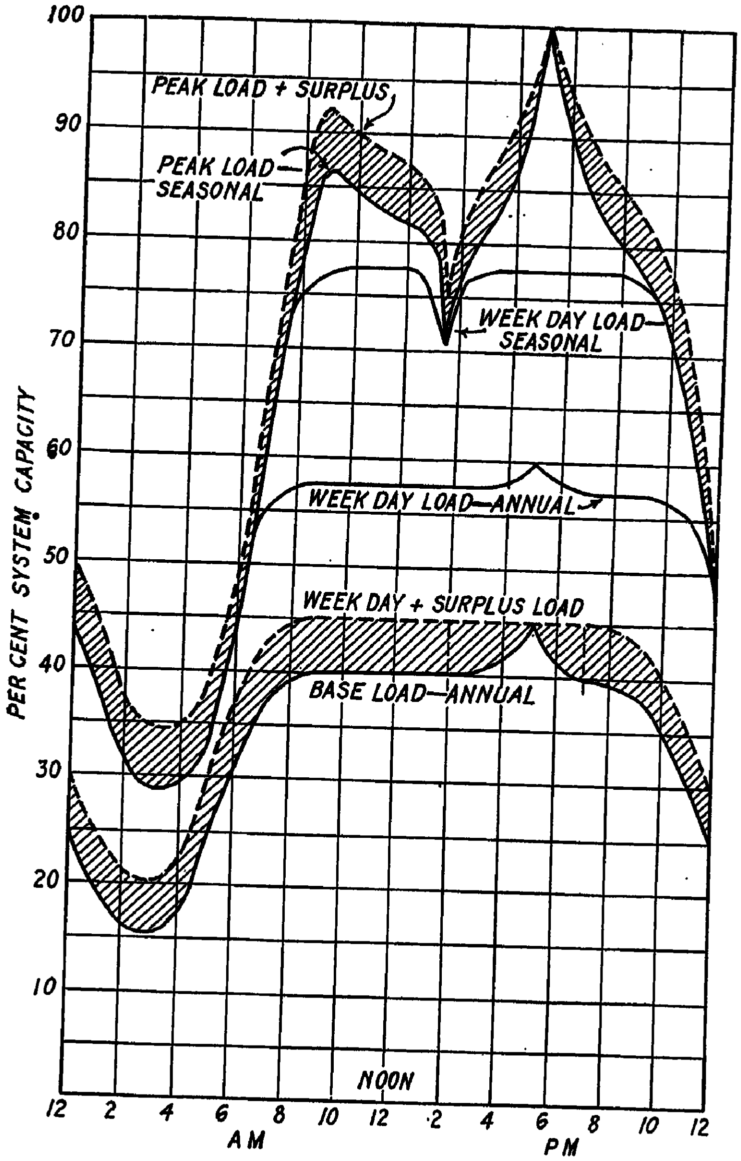


Fig. 2. Typical distribution of annual system peak load among system generating stations showing method of carrying "surplus" load in addition

among the various generating stations of a typical system, and also the cutting off of this load during system peak hours. The greater part of the surplus will be furnished from the most efficient apparatus whose capacity factors will be materially increased.

Base-load apparatus now operating at from 50 to 60 per cent load factor then will operate at from 70 to 80 per cent, a loading that will make it possible to revolutionize the design of generating plants. There will be no question about the advantages of high pressures and temperatures, steam extraction and reheating, and the leviathan prime movers no longer will be needed to save space and meet the conditions of variable load. This should make it possible to standardize the generating equipment and promote quantity production with a tremendous saving in development costs.

It is possible to forecast generating plants of relatively simple design with one steam generator for each prime mover and with most of the equipment in the open air. It is reasonable also to anticipate the use of the double thermodynamic cycle. The mercury boiler and turbine may no longer be a curiosity and there may be competition from other high-boiling-point liquids having suitable vapor tensions.

Those who can remember the "modern" power plants of 1900 with its wonderful performance of 4 lb. of coal per kw-hr., and who know that during the last decade the coal rate of the latest equipment has dropped from 2 to 1 lb. per kw-hr., will not condemn the suggestion that it may be 0.5 lb. per kw-hr. by 1940.

PRODUCTION COSTS

Relative to what this surplus energy will cost, it is but fair to state that several complications are to be faced. Familiarity with hundreds of computations, some of which are based on most reliable data, compels the conclusion that no two plants will produce similar results. The best that can be done is to portray what is considered to be an average. Systems most favorable to the surplus load will have costs averaging lower, and those unfavorable will have costs higher than those to be given.

It is axiomatic that the first 5 per cent addition of surplus will produce the greatest immediate saving, also that the saving will increase proportionally with an increase in the cost of coal. Additional increases in surplus load produce less and less saving until a point is reached where by reason or lower capacity-use the increase in the cost of fuel offsets the efficiency increase.

Admitting the pictorial method used in dealing with a matter requiring knowledge of many local conditions for any real accuracy, what are considered to be average costs are tabulated for the 18,000,000,000 kw-hr. available in 1930 and the 30,000,000,000 kw-hr. to be available in 1940. Assumptions upon which Table II is based are as follows:

1. Coal of 13,000 B. t. u. per lb., at $4.00 per ton.
2. Coal cost is 80 per cent of the total production cost.
3. The actual cost is 110 per cent of the production cost.
4. All fuel saving on normal load is credited to the surplus load.
5. Charges for capital are omitted.

TABLE II—ESTIMATED COST OF SURPLUS POWER COST IN MILLS PER KW-HR.

Surplus	1930	1940
1st 5 per cent	0.4	0.25
2nd 5 per cent	0.6	0.35
3rd 5 per cent	0.9	0.50
4th 5 per cent	1.5	0.75
5th 5 per cent	2.3	1.25
6th 5 per cent	3.5	2.00
Average for 30 per cent	1.5	0.85

Assuming that this portrayal will appear incredible matters may as well be made worse by suggesting that if by 1940 there is in use some 5,000,000 kw. of double-cycle apparatus, the first 10 per cent addition of surplus will be free of cost, and the average cost for the 30 per cent surplus will be less than 0.5 mill per kw-hr. It should be pointed out that there is a somewhat perplexing question regarding fixed charges for new and possibly more expensive equipment, such as the mercury-cycle boiler and turbine. This more efficient apparatus might be warranted by the surplus, but not by the normal load. Some attempt has been made to allow for this in the table of costs.

How Surplus Power Can be Used

As previously mentioned, this proposal is based upon the absorption of surplus energy in electrochemical and electrothermal processes. Electrochemical processes will come first since they are adapted to the requirement of regulation and of intermittent use. Electrothermal processes are best adapted to the use of night and week-end power. There are but few electrochemical processes now capable of adaptation to this kind of use and only one of them is immediately ready. There is much to warrant the expectation that when the advantages of this cheap power become well known, a way will be found to adapt many more processes to its use—at least to some extent.

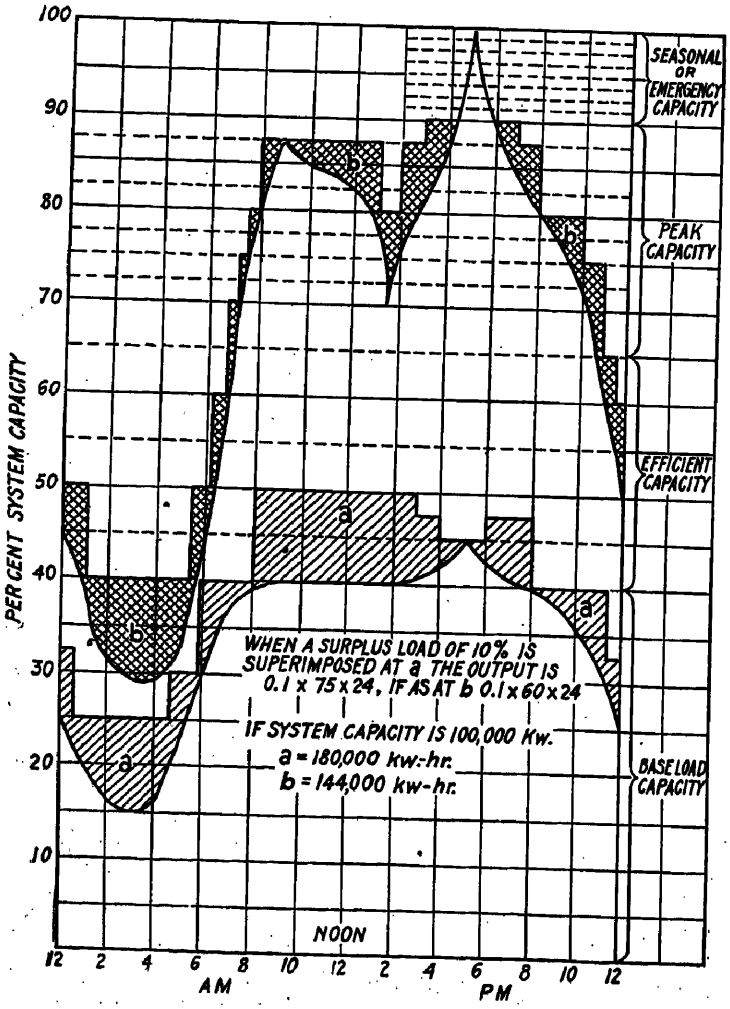


Fig. 3. Method of improving station efficiency by superimposing a "surplus" load equivalent to 10 per cent of the system capacity

Electrolytic cells for the decomposition of water by electric current have been in use for many years. There are several types that will meet the technical requirements of intermittent and variable use of energy. In addition, there is reason to believe that salt cells equally suited to the use of off-peak power will be available shortly. From an economic point of view, first cost and maintenance are of great importance and this narrows the choice of types of cells. However, a careful survey of all types of cells capable of using off-peak power leads to the conclusion that water cells will be of greatest value, salt cells next in value, and that there are other possibilities relating mostly to the electrolysis of organic compounds.

Cost of Many Products Reduced

Without reaching very far into the field of synthetic chemistry and by just touching upon the metallurgical possibilities, a hasty survey reveals some of the possibilities, for it is certain that no matter how great the quantity nor how cheap this surplus energy may be, it will not be used unless profit results. Assume that the materials of manufacture available are air, water, coal, salt, oil, off-peak energy, and energy at standard rates. As products then:

1. Nitrogen can be obtained from air by burning out the oxygen with hydrogen.
2. Water and off-peak energy will produce hydrogen and oxygen.
3. From coal will be obtained pure carbon, carbon monoxide, and carbon dioxide. By use of the coke oven, coke and many hydrocarbon by-products can be made.
4. Salt and off-peak energy will produce chlorine, caustic soda, and hydrogen.
5. From oil, gas and many hydrocarbons can be manufactured.

Well-known chemical processes and usable catalytic reactions are available to convert these materials into a variety of products which can be used in the district in which they are made. Many of these dependent industries will be new to the district, bringing to it an increase of population; all will require more or less power at the standard rates.

The list of products possible of manufacture is too formidable to be reproduced here; by way of illustration only a few are mentioned. Costs given represent the total estimated manufacturing costs:

1. Hydrogen at 20c. per M. cu. ft.
2. Oxygen at 20c. per M. cu. ft.
3. Nitrogen at 15c. per M. cu. ft.
4. Carbon monoxide at 20c. per M. cu. ft.
5. Carbon dioxide at $5 per ton.
6. Chlorine gas at 0.5c. per lb.
7. City gas of 560 B. t. u. at 25c. per M. cu. ft.
8. Caustic soda at $20 per ton.
9. Carbon black at 3c. per lb.
10. As examples of final products may be mentioned synthetic ammonia and city gas.

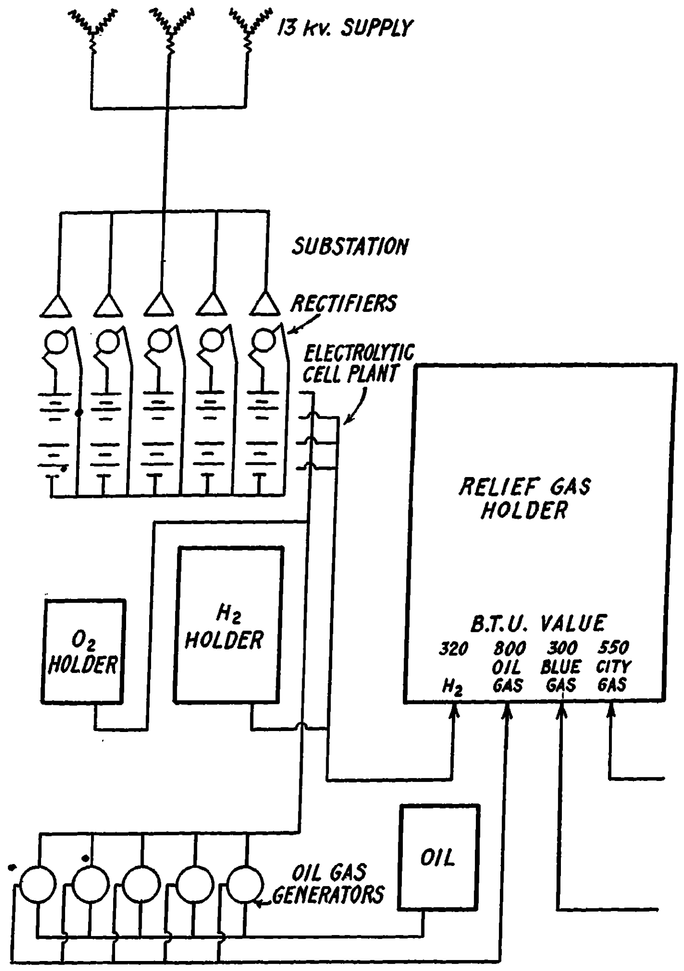


Fig. 4. Schematic diagram of a plant designed to absorb surplus electric energy in the production of gas

It is a well-known fact that when hydrogen costs 40c. and nitrogen 20c. per M. cu. ft., they aggregate 60 per cent of the cost of ammonia when produced at $70 per ton. It is reasonable to assume, therefore, that ammonia could be produced for $50 per ton when manufactured from constituents made from surplus power.

It is known also that 250 cu. ft. of oxygen and 5 gal. of oil of 160,000 B. t. u. per gal. will produce 1,000 cu. ft. of 800 B. t. u. gas and this can be diluted by adding hydrogen or blue gas (uncarbureted water gas). With oil at 4c. per gal., 500 cu. ft. of oil gas and 500 cu. ft. of hydrogen will produce 1,000 cu. ft. of 560-B. t. u. gas at less than 28c. per M. cu. ft. in the holder. Natural gas of 1,100 B. t. u. must be sold at 40c. per M. cu. ft. at the end of the pipe line to compete with this cost.

Oxygen always can be used with coke and water to produce a metallurgical reducing-gas mixture, or it can be used for air enrichment in the blast or open-hearth furnaces, when it can be had cheaply enough. Hydrogen is a fuel gas and also a reducing gas and can also be used in metallurgy when its cost is low enough. When the availability of these gases in large quantity is assured and their cost becomes lower than 35c. per M. cu. ft., they will find a market by reason of the economies their use will produce. This market will enlarge as the price of the gas lowers. If the surplus energy costs shown in Table II are put into effect and no better apparatus than that now available is used, oxygen and hydrogen can be sold profitably at 25c. per M. cu. ft. in 1932 and at 20c. per M. cu. ft. or less in 1940.

All estimates of cost have been based upon the use of new equipment for converting a-c. to d-c. energy. The cost of complete plants to furnish oxygen and hydrogen at uniform hourly rates from surplus power are estimated as shown in Table III.

TABLE III—ESTIMATED COSTS OF COMPLETE PLANTS FOR FURNISHING OXYGEN AND HYDROGEN BY THE USE OF SURPLUS POWER

Input capacity of plant in kw.	Load factor	Cost per kw.
10,000	0.90	$50.00
20,000	0.85	47.50
30,000	0.80	45.00
50,000	0.75	37.50
100,000	0.70	35.00

Substitution of mercury arc rectifiers for motor-generators would lower the cost and there always is the hope that some cheap and effective form of commutating device or electrolytic rectifier may be invented that would deliver pulsating direct current. If apparatus of this type could be obtained at about $5 per kw., oxygen and hydrogen each could be produced for about 10c. per M. cu. ft.

WHAT SURPLUS POWER NOW AVAILABLE WILL DO

It may be appropriate at this point to give an idea of what all the surplus energy alleged to be available would do in terms of products:

1. Each a-c. kw-hr. will produce about 9 cu. ft. of gas, of which 6 is hydrogen and 3 oxygen.
2. The 3 cu. ft. of oxygen with coal and water, in the Bosch process, will produce 12 cu. ft. of hydrogen.
3. One cu. ft. of hydrogen with air and heat will deliver two cu. ft. of nitrogen.
4. The 18,000,000,000 kw-hr. estimated as available in 1930 therefore would produce 108,000,000 M. cu. ft. of hydrogen and 54,000,000 M. cu. ft. of oxygen.

The oxygen could be sold at cost. The hydrogen would permit the manufacture of about 1,200,000 tons of synthetic ammonia containing nearly 1,000,000 tons of fixed nitrogen. If instead the gases were used with oil to make 555-B. t. u. city gas, there would be required about 1,062,500,000 gal. of oil and the hydrogen, and 108,000,000 M. cu. ft. of blue gas. The total annual output of city gas would be 432,000,000 M. cu. ft.

Excepting only the use of the gases in metallurgy, the manufacture of fixed nitrogen and fuel gas are the two least remunerative uses for the gases. They have been mentioned because the market for both is large and demonstrates that there need be no delay in putting off-peak capacity to work.

Consider, as a further example of what could be accomplished, that a company were to construct a plant for manufacturing gas by the use of surplus power as outlined in this article, and at the same time build an electric plant especially adapted for supplying such power in addition to its regular load. Assume, for the sake of example, that the output of the electric plant is rated at 200,000 kw., allowing 10 per cent spare capacity to meet the necessity for continuous service. Such a plant could be built for 80 per cent capacity-use and the energy taken by the electric system as base-load power would be restricted to 60 per cent load factor as being sufficient to best meet the requirements of that system. The cost of such a plant would be $100 per kw., or a total cost of $20,000,000 for the 200,000-kw. capacity. This low plant cost would be due to the simplicity of design possible with high-load-factor apparatus. Fixed charges on such a plant would be 12 per cent, thus providing for a 20-year replacement period.

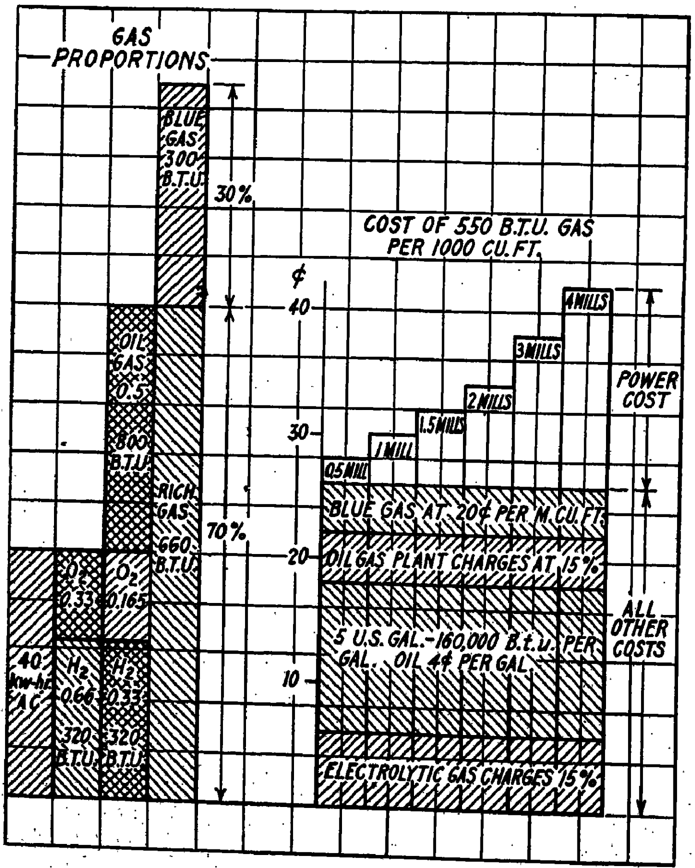


Fig. 5. Chemical composition and costs of gas produced from surplus electric energy. It may be noted that with each successive 5 per cent increment in surplus power used, the cost per kw-hr. increases from 0.5 mill to 4 mills

TABLE IV—GAS PLANT COSTS

Electrolytic Plant		
60,000-kw. converting plant @ $20		$1,200,000
55,000-kw. cell plant @ $20		1,100,000
Gas holders, 3,000,000 cu. ft.		400,000
Total		2,700,000
Fixed charges at 15 per cent		405,000
Products		
Oxygen	1,051,200 M. cu. ft.	
Hydrogen	2,102,400 M. cu. ft.	
Total	3,153,600 M. cu. ft.	
Operation		
350,400,000 kw-hr. @ 1.76		616,704
Operation and maintenance		50,000
Production cost		666,704
Fixed charges		405,000
Total cost for 3,153,600 M. cu. ft.		1,071,704
Cost of oxygen and hydrogen per cu. ft.	.34c	
Gas Plant		
Gas plant including holders		3,000,000
Fixed charges at 15 per cent		450,000
Operating Costs		
1,051,200 M. cu. ft. oxygen		357,235
21,024,000 gal. oil at 4c		840,000
Operation and maintenance		40,000
Cost of 4,204,800 M. cu. ft. 800 B. t. u. gas		$1,238,105
Cost per M. cu. ft.	29.4c.	
Add 2,102,400 M. cu. ft. hydrogen		714,460
Cost of 6,307 M. cu. ft. 660-B. t. u. gas		1,952,664
Cost per M. cu. ft.	30.9c.	

At an annual load factor of 60 per cent, which is assumed for the base load, the energy output for the electric system would be 1,051,200,000 kw-hr. At this load factor the thermal rate would be about 12,500 B. t. u. per kw-hr., which can be taken as equivalent to one pound of coal. Coal rate is assumed to be 80 per cent of the production cost, which is about 95 per cent of the total cost. Taking coal at $4 per ton the energy cost would be 2.64 mills per kw-hr. The price which ought to be obtained would therefore be about 5 mills per kw-hr. The plant, however, would be loaded to 80 per cent load factor, as the gas plant would be able to use the surplus power in gas manufacture. Based on this load factor the annual output would be 1,401,600,000 kw-hr., and the surplus power output 350,400,000 kw-hr.

The thermal rate based on 80 per cent capacity-use would be 11,500 B. t. u. per kw-hr. This low thermal rate would be obtained by the use of high pressure, high temperature, steam extraction, and reheating. On the basis used for the 60 per cent capacity, the cost of this energy would be 2.42 mills per kw-hr. It is estimated that 75 per cent of this output would be sold at 2.64 mills, leaving the net cost of the surplus as 1.76 mills per kw-hr.

To raise the load factor of the electric system from 60 per cent to 80 per cent, would require a gas plant capable of absorbing about 60,000 kw. Fig. 4 shows a schematic diagram of such a plant. Cost estimates for this plant and its operation are shown in Table IV.

In Fig. 6 is indicated the cost of 800-B. t. u. oil gas when oxygen and oil are used, and the cost of 660-B. t. u. mixed gas when the hydrogen also is used. The costs are related to the cost of the surplus energy.

The feasibility of utilizing surplus power by the method proposed seems to be well established by the examples given. From the standpoint of the power companies, adoption of such a plan would be quite advantageous and it is obvious that the general public would benefit as well through the lessening of manufacturing costs of numerous commodities. It is hoped that this article will revive discussion on this all-important subject, and that it presages the day when some intelligent use will be made of surplus power.

◆ ◆ ◆

Cooperative Work on Joint Pole Use

Since both telephone and electric service customers must be reached by the two utilities it is obvious that the joint use of poles would have many advantages to the utilities, the customers, and the community. Important operating problems resulting from such close proximity are receiving joint study; new problems constantly arise with developments in practise. The present status of cooperative study of joint use is outlined here.

By J. C. Martin* and *H. L. Huber

Associate A. I. E. E.
Middle West Utilities Company
Chicago, Ill.

Member A. I. E. E.
American Tel. & Tel. Company
New York

PRINCIPLES and practises for the use of wood poles jointly by electric supply companies and communication companies as recommended by the Joint General Committee of the National Electric Light Association and the Bell Telephone System under date of February 15, 1926 contemplated that each party to such joint use should:

1. Be the judge of the quality and requirements of its own service, including the character and design of its own facilities, both now and in the future.
2. Determine the character of its own circuits and structures to be placed or continued in joint use; and determine the character of the circuits and structures of others with which it would enter into or continue in joint use.
3. Cooperate with the other party so that in carrying out the foregoing duties proper consideration will be given to the mutual problems which may arise, so that the parties can jointly determine the best engineering solution in situations where the facilities of both are involved.

From the foregoing it may be observed that while each party retains full responsibility for its own problems, emphasis is placed upon the mutual advantages accruing from conscientious effort to find the best over-all engineering solution in each particular situation. These principles are among the important recommendations during a decade of cooperative studies, and they form the basis upon which practically all cooperative work is being carried forward.

It is the purpose of the following paragraphs to describe briefly what has been done by the joint subcommittee on development and research and what is being done in connection with the engineering and economic problems encountered in joint use.

CONSTRUCTION PRACTISES

From the inception of the joint use of structures, joint-use construction practises have undergone almost constant change and improvement and continued development is to be expected for the future. However, many of the fundamental requirements for securing satisfactory conditions on jointly used poles were recognized at an early date and form the basis for present day practise.

In so far as practicable, power wires, because of their relatively greater mechanical strength, have been assigned to the upper positions on jointly used poles. Also, with power wires in the upper position, telephone linemen are not required to climb through power circuits, with the exact nature and characteristics of which they are not always familiar.

Good practise dictates sufficient clearance between levels of power and telephone wires to allow for safe working. Where wires to street lights and underground connections to aerial plant require vertical runs on jointly used poles, their location, insulation, and mechanical protection have received careful study, looking toward the elimination of hazards to workmen. Sufficient clearances between vertically run circuits of one type and the equipment of another utility on the same pole have been found to be most important from the standpoint of avoiding service-interruption to both power and telephone systems. In this connection it is well to note that any situation where insufficient clearance between power and telephone facilities is provided may result in trouble for one or both.

Present day construction standards therefore emphasize the necessity of maintaining proper clearances as well as strength of construction; and experience shows that where these standards have been practised, trouble from these sources has been kept within a reasonable limit. The joint general committee is giving

---

From "Status of Cooperative Work on Joint Use of Poles," (No. 31-24) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931, as Part IV of a symposium on coordination of power and telephone plant.

careful consideration to the matter of construction standards on jointly used poles. Pending the development of complete specifications covering recommended practises under various conditions, the National Electrical Safety Code is recommended as a guide to practise.

PROTECTIVE DEVICES

Both telephone and electric supply circuits are equipped with protective devices fundamentally the same in pinciple and falling within two general classifications:

1. Those which provide protection from abnormal voltages consisting of protector blocks in the telephone plant and lightning arresters in the electric supply system.
2. Those which provide protection from abnormal currents consisting of heat coils and fuses in the telephone plant and fuses and circuit breakers in the electric supply systems.

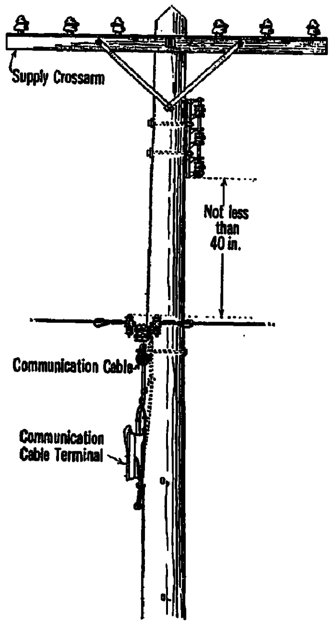


Fig. 1. An example of good practise in joint pole use showing one method of accomplishing satisfactory conditions

These protective devices are of secondary defense against abnormal conditions which it is impracticable to avoid either by design or through adherence to construction standards.

In spite of all practicable precautions with regard to clearances, strength of construction, and insulation, accidental breaks occur both in power and in telephone wires; therefore, and also because of the limitations of protective devices, joint use with certain types of circuits is questionable. Differences of opinion exist between engineers as to the degree of hazard involved in joint use between telephone plant and power circuits of various types, voltages, and connected capacity. This problem has increased in importance as the use of higher distribution voltages and greater generating capacities have been adopted. The joint subcommittee on development and research now is studying several typical rural and suburban areas to determine the over-all advantages and disadvantages of the use of higher distribution voltages and of joint use with these voltages under present conditions.

In connection with these problems the joint committee carried on experimental work to determine the characteristics of various types of fuses. Tests made in a laboratory where 20,000 kv-a. of generating capacity was available showed the range of dependability that could be placed upon the various fuses for interrupting voltages ranging from 2.3 to 13.2 kv. Another phase of experimental work covered breakdowns with direct current and with 60-cycle alternating current, and a complete cathode ray oscillographic study of the behavior of carbon-block protectors and neon and vacuum tubes under steep wave fronts. These tests showed that the carbon-block protector has a breakdown point with all types of applied wave fronts that is sufficiently fast and low to protect the insulation now used in the communication plant. The shortcomings of these blocks lie in their tendency to ground the circuit permanently when forced to carry current for any appreciable length of time. Tests with steep wave fronts were carried to a rate of rise of 36.5 kv. per microsecond.

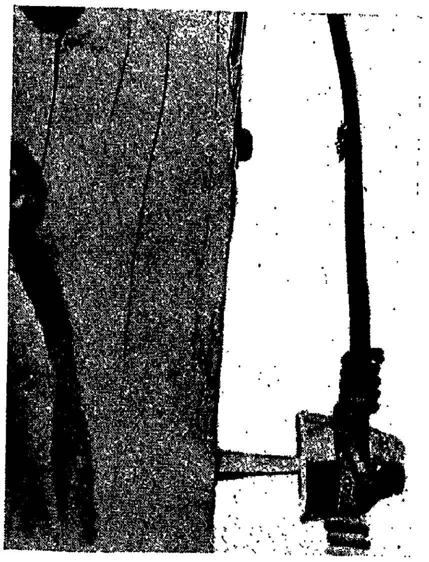


Fig. 2. An example of improper construction. Wire was pulled against through-bolt resulting in an insulation failure which interrupted both services. Wire removed to permit photographing

MUTUAL RESPONSIBILITY FOR PROTECTION

The problem of adequate protection of the telephone plant in joint use obviously cannot be solved by the development of telephone protective devices alone; protective devices in the power system are of equal importance. One problem in present development and research work is the fixing of the part that the protective devices on each system must play in abnormal conditions; the burden of weaknesses in the protective equipment of one system must not be thrown upon the protective equipment of the other. Therefore, the next step in this investigation is a determination of the over-all characteristics of power circuit and telephone circuit protection under typical conditions of contact between the two.

- One of the important functions of the power-system protective devices is that of clearing power-system faults in a reasonable time interval. Obviously, telephone protective equipment cannot be expected to prevent damage to telephone plant in case of contact between the wire circuits of the two utilities when power-system protective devices fail to operate and the physical contact of the circuits is maintained over an indefinite period of time.

All of these problems are being approached upon the basis of determining the best over-all engineering solution to the end that both systems may provide their services in the most convenient and economical manner.

The various operating problems which have arisen almost since the birth of the power and telephone industries, and the investigations conducted by the joint subcommittee on development and research, indicate the importance of giving careful consideration to the inductive coordination features of joint use and of including this factor in studies of the relative advantages and disadvantages of joint use as compared with separate lines. This factor, of course, should be considered from both its technical and economic aspects.

In the inductive coordination of the two distributing systems much can be accomplished by cooperative advance planning. In urban areas where the telephone circuits are largely in cable, there is about a two-to-one ratio in the inductive effects between a joint line and separate lines across the street. In rural areas where the telephone circuits are largely open wire, the ratio of the inductive effects on joint lines as compared with separate lines across the highway is much greater—other things being equal.

In urban areas the power and telephone companies through cooperative planning frequently can arrange to establish important power feeders and telephone circuits on separate streets, thereby avoiding large inductive effects, and permitting more extensive joint use of branch lines. A careful review of the equipment used on the power and telephone circuits and the introduction of operating practises designed to limit the inductive susceptiveness of the telephone circuits and the inductive influence of power circuits, form an important part of advance planning and cooperation.

In the case of rural lines where the telephone circuits are largely in open wire and the exposures between particular circuits are likely to be long, joint use is not always practicable. In these cases locations for separate lines usually are available. Furthermore, joint use in rural areas is not always economical from a purely construction standpoint. Joint use with telephone toll circuits or power transmission lines has not, in general, been found desirable.

◆ ◆ ◆

Reactance Relay Performance Reviewed

Results of a year's experience with reactance-type distance relays in the South is interpreted as demonstrating the correctness of the reactance principle. Difficulties that have arisen as a result of interconnections which operate near the stability limit, and other operating problems, are outlined here with resulting conclusions.

By E. E. George
Member A. I. E. E.

Tennessee Electric Power Company
Chattanooga

OPERATING EXPERIENCE has shown the correctness of the major principles of design and application of reactance-type distance relays on the system of the Tennessee Electric Power Company. Several difficulties have been encountered, but these have been given less weight than the prime considerations of carrying high loads safely during emergencies and of clearing the majority of faults selectively during all operating conditions.

On February 9, 1930, the company installed three reactance relays at its Great Falls hydro plant. These relays were of the normal-speed distance type (LB-1) furnished by the American Brown Boveri Company, but built in Switzerland by Brown Boveri, Limited. This is believed to be the first installation of reactance relays in this country. Since that time 24 more of the LB-1 relays and 27 General Electric type GAX relays have been installed, making a total of 54 distance relays of

---

From "Operating Experiences with Reactance Type Relays" (N . 30-181), presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

the reactance type on that system. In addition, six high-speed distance relays of the Westinghouse impedance type (HZ) are now being installed.

In Figs. 1 and 2 are shown typical wiring diagrams for the two types of reactance relays and how the test facilities preferred by the Tennessee company have been applied. If it is desired to use the auxiliary equipment offered by one manufacturer for securing ground protection as well as phase protection, the test scheme becomes more complicated.

Reasons for the rapid installation of these new types of relays may be of general interest; herewith is given a tabulation of the variation in short-circuit kv-a. on the various high-voltage buses of the system. This variation is caused chiefly by changes in operating conditions with steam and hydro generation at widely separated locations. The tabulation covers the total short-circuit kv-a. on the bus; of course, any one outgoing line has substantially less current.

The location of circuit breakers on the 154-kv. and 110-kv. systems, together with the type of phase protection now in service at each are shown in Fig. 3. Many of the line sections are of No. 2/0 copper or its equivalent. The map, together with the table of short-circuit kv-a., shows why the short circuit at the end of a long section may be even lower than the normal load of the line. Furthermore the opening of a section under fault frequently requires the adjacent sections to carry as much as twice normal load for a minute or more. Over-current relays (and relays having over-current pick-up) have proved inadequate and almost useless under these conditions.

TABLE I—VARIATION IN SHORT-CIRCUIT KV-A. ON TENNESSEE ELECTRIC POWER SYSTEM

	Maximum	Minimum
Arlington	680,000	160,000
Centerville	360,000	170,000
Great Falls	480,000	210,000
Hales Bar	600,000	250,000
Ocoee No. 1	780,000	250,000
Ridgedale	560,000	220,000
West Nashville	390,000	180,000
Wilson Dam	800,000	150,000

The principle of the distance relay finds a ready application in handling this situation. Reactance-type relays were preferred over the impedance type since it is thought that the former give a more accurate measurement of the distance to the fault by being independent of arc resistance.

Certain factors relating to the installation and operation of both types of relays have been demonstrated conclusively and are outlined in the following paragraphs.

High-voltage-potential supply is necessary in practically all cases because incorrect operation is likely to result when running on low-voltage supply. After trying various substitutes, the potential transformer has proved the best, and in the long run the most economical source. Pilot indication is highly desirable on potential supply; neon lamps serve this purpose admirably.

By the use of distance relays each section of line is protected independent of other sections and selectively without cascading relay settings.

The amount and location of generating capacity has no appreciable effect on the time of clearing faults. Loads much beyond the sustained thermal capacity of a transmission line can be carried without tripping, but if the voltage is low enough to indicate a fault in the protected zone, a secondary current of about two amperes or more will operate the relay in a predetermined time. Impedance releases or starting units on reactance relays, however, should be set rather high—say at ten amperes or more.

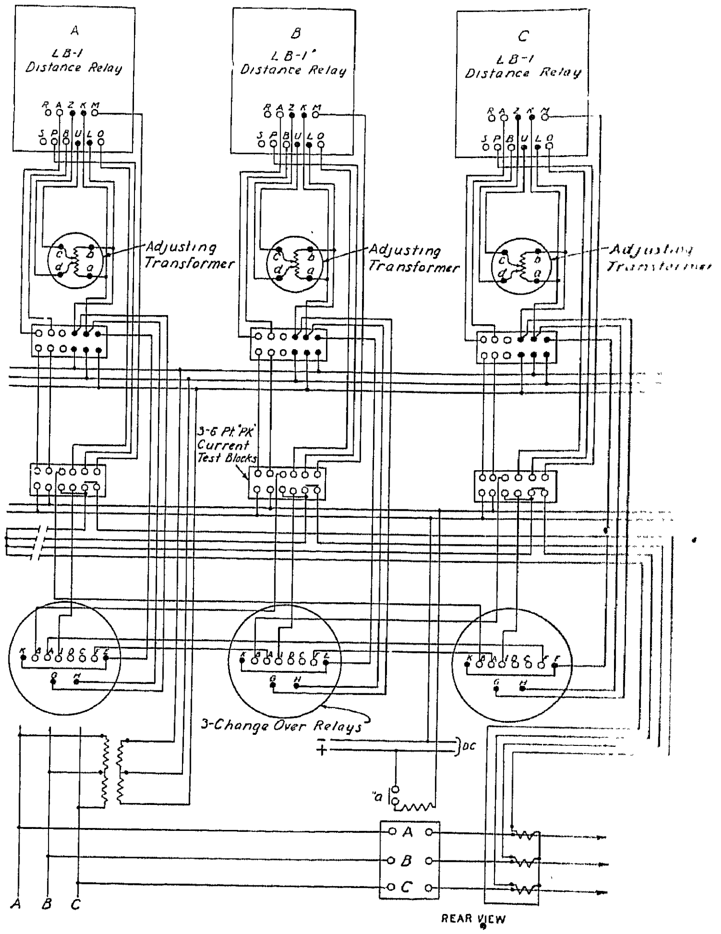


Fig. 1. Wiring diagram for type LB-1 distance relays

Relays of this type can also be used for fast bus protection, but it is not possible to obtain correct directional action in all cases for heavy faults close to the station. It is recommended that the buses of important stations be protected independently so that the distance relays may be used for outgoing protection only.

Both types of reactance relays have been found to operate on arc faults in the same time as on solid short circuits, even up to the longest arcs that could be maintained on the system.

The cost and importance of distance-relay installations justify maintaining complete and accurate operating records, and a careful study of these records after they are obtained. This does not mean, however, that relay settings or schemes should be modified on account of one report of incorrect operation; it is too difficult for the average operator to determine exactly what happens and except in case of careful observation on staged test, too much weight should not be given to any one reported erratic performance.

Quick-trip ammeter installations as used to record neutral-ground current have been very helpful in analyzing relay operations. The absence of a ground-current record indicates a phase-to-phase short circuit which should operate the distance relays. These graphic ammeters frequently show ground current at the same time the distance relays operate, indicating a two-phase-to-ground short circuit, or a phase-relay operation on a single-phase-to-ground fault. Automatic oscillograph installations should also be very valuable in analyzing relay operations especially on occasions when the station operator's time is limited.

In this territory most of the high-voltage phase-relay operations occur in June, July, and August, during the height of the lightning season, thus giving a rather limited time in which to make and note the effect of any changes in relay installations. This means that in order to record the effect of any improvement or revision before the lightning season ends, questionable or incorrect operations must be followed up promptly. The lightning storms are not only concentrated during the summer months, with a peak in July, but these storms also occur most frequently in the afternoon. This extreme concentration of trouble greatly complicates relaying and dispatching problems due to independent troubles occurring close together, or even simultaneously. A second line may relay out before the first line can be closed back in, thus leading to confusion in the operating records as well as to interruptions to customers provided with two or more sources of supply, even though none of the circuits are in trouble permanently.

One type of reactance relay is equipped with a distance indicator which has been very helpful in studying the conditions under which the impedance release operated. It would also be desirable to have more than one target on the step-by-step distance relays so that there would be a record of whether the relay tripped on instantaneous, intermediate, or back-up time. It has been found impracticable to determine this by watching the relay, even on staged tests.

For distance relays, no entirely satisfactory method of low-voltage routine tests has been devised but they have been checked by staged tests during installation and in case of questionable operation, occasionally thereafter.

In addition to the foregoing conclusions regarding distance-relay performance there are certain questions which in the opinion of the writer have not been definitely answered as yet. These together with some of the evidence that may be helpful in reaching conclusions, especially when and if corroborated by further experience, are outlined in the following paragraphs:

Table II is a condensed summary of the operation of distance relays on this system from the dates of their installation up to the present time. Details of these operations are tabulated in the complete paper.

Apparently the operation of all types of these relays is highly satisfactory on radial feeders. The only difficulties arise on trunk lines and on interconnections where wide variations in power factor during load swings seems to be one of the chief difficulties.

The performance of distance relays under out-of-step conditions is still uncertain; this liability, however, is not confined to these relays, as it is definitely known that the old impedance relay will operate quickly on any out-of-step condition if the current peaks exceed the pick-up value for a short time. Many interconnections are subject to more or less prolonged surging somewhat below the stability limit and relays should hold in all such surges. This is one of the problems on the East Tennessee interconnection.

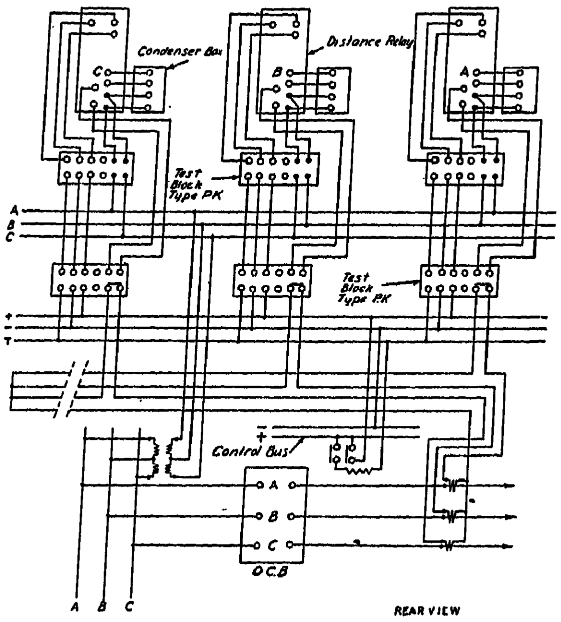


Fig. 2. Wiring diagram for type GAX distance relays

Unfortunately, however, there is no precedent for saying that a line should or should not relay on out-of-step conditions. As a result of relay subcommittee investigation, it has been suggested though tentatively that severe out-of-step conditions should cause relay operation, but only at one location which should be at the point of maximum voltage variation.

Operating experiences also show that impedance releases or starting units should have reset values fairly close to the release values, particularly if the starting unit is non-directional. Otherwise a fault may be cleared promptly at some other location, but the resulting surging or readjustment of power flow may be sufficient to hold the relay released and cause incorrect operation.

TABLE II—SUMMARY OF REACTANCE-RELAY OPERATIONS

Correct operations	47
Questionable operations	7
Wrong operations	0
Inadequate potential supply	18
Total	72
Analysis:	
Correct operations	
Line relayed at one end only	3
Same line relayed simultaneously at other points	28
Line relayed while being supplied from one end only	5
Back-up protection	3
Low-voltage bus failure	1
Bad synchronizing	5
Bus protection	2
Total	47
Questionable operations	
Out-of-step conditions	7
Total	7
Inadequate potential supply	
Cross-phased	3
44-kv. trouble	5
Bushing potential devices	5
110-volt secondary trouble	5
Total	18

In this connection it would be advantageous for the starting units to be made more readily adjustable. At present they are designed and factory-adjusted so as to give back-up protection to only two or three average sections of line, while the distance measuring element is flexible and can be adjusted for almost any combination of sections. The time setting on intermediate and back-up operation of step-by-step distance relays should be rather long—probably 60 cycles or more for the intermediate time if used on heavy interconnections. This is a tentative conclusion from operating experience on the East Tennessee interconnection.

The instantaneous element on a distance relay may operate too quickly if the relay trips under two or three cycles, since incorrect operation may occur due to breaker adjustment. A certain definite time is required for proper directional discrimination, and it does not seem to be wise to try to speed up the initial time too much on certain types of relays.

Distance relays can be used successfully on the same system with other types of relays, but if the ordinary types of relays operate slowly under minimum generating conditions, the distance relays will operate frequently ahead of them. It is entirely feasible however to use separate and independent ground protection with these relays. For ground protection it has always been the practise of this company to use current directional ground relays and no change was made in this practise when distance relays were installed for phase protection; however, both manufacturers have developed schemes of ground protection using distance relays and star potential supply.

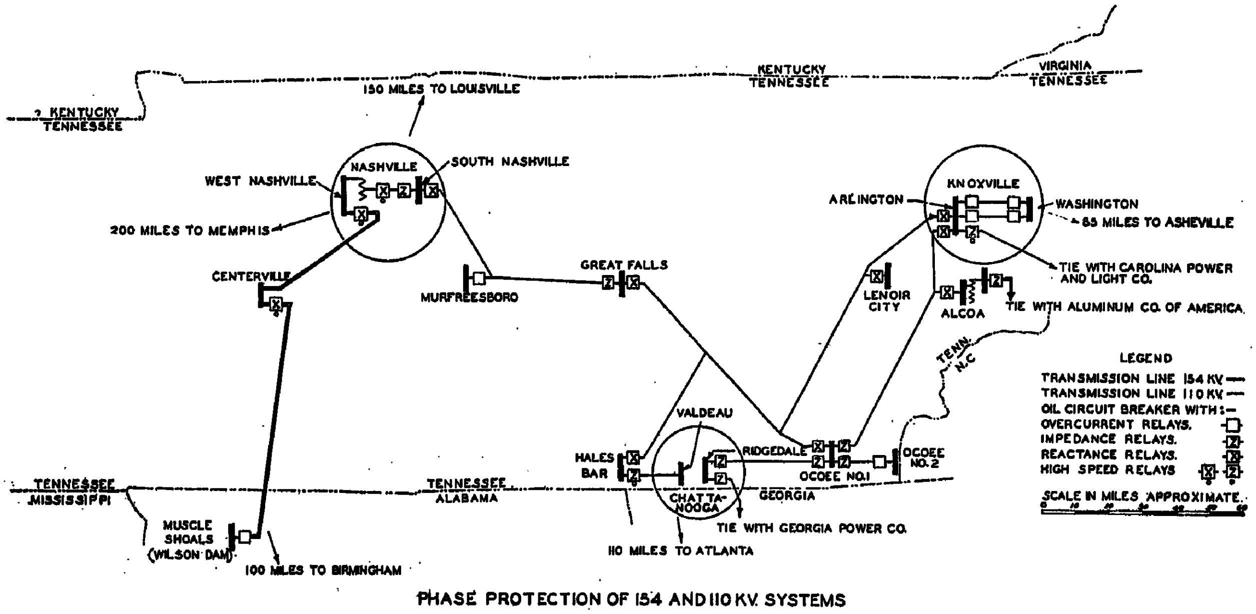


Fig. 3. Schematic diagram depicting distance relay applications on the Tennessee Electric Power Company's system

Electrical Porcelain

Simple comparative tests of American and European samples of standard insulating porcelains reveal strikingly similar characteristics in the finished products in spite of variations in raw materials and manufacturing processes.

By H. M. Kraner

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

ALTHOUGH the investment in the insulators used on a modern transmission line represents only a very small percentage of the total cost of the line, much depends upon their continuous and satisfactory performance as an electrical insulator and a mechanical support.

While the electrical industry was still young, the ceramic industry was operating on rule-of-thumb methods. As a result, it was difficult for the electrical engineer to know anything more about porcelain than that the product of one manufacturer was satisfactory whereas that of another gave trouble under the various new conditions which were being encountered. Recent advances in silicate chemistry, made possible by the use of the petrographic microscope, and the application of fundamental mechanical tests to these materials, has done much, however, to diminish this handicap. As a result, manufacturing methods have been improved greatly, and porcelains of much better quality and greater uniformity now are being produced.

Nearly all the many kinds of porcelain now used for transmission line service are made essentially of clays, flint (quartz) and feldspar. Obviously porcelains having all kinds of properties might be made by varying the proportions of these constituents; by good and bad methods of mixing and forming, and by firing at various rates and for various lengths of time.

The clays are used for their unique plasticity which makes possible the molding and drying of the pieces. Flint (quartz) is a somewhat inert refractory material which during firing adds viscosity to the mass and also acts as a skeleton for the entire mass at that time. Feldspar is a melting constituent which, when fused, carries the clay and some of the quartz into solution in the resulting glass matrix. Thus the clays are all-important in the forming operation, while the feldspar is particularly important in the firing process.

Unlike many manufactured products in which the final operation before assembly brings the piece to the prescribed dimension, porcelain undergoes the firing process with a 12 per cent shrinkage after the final dimensioning operation. Any irregularity in the manner in which the piece is placed or fired may affect its ultimate dimensional accuracy and hence the firing as well as the composition is extremely important.

European practise is to fire to approximately 1,400 deg. cent. whereas only 1,200 deg. cent. with a longer firing time is customary in America. Analyses show, however, that the chemical composition of these porcelains is very similar.

European contemporaries have conducted much more fundamental testing on various ceramic materials than has been done in this country. American tests have been limited to those properties which are directly applicable to, and of value in, the finished products—tensile strength, compressive strength, cross-bending strength, impact and dielectric strength. Of these the cross-bending test seems to be most suitable for fundamental indication of the merit of a porcelain. Small inaccuracies in the test piece do not greatly affect the results obtained, and the variation in diameter does not affect the modulus of rupture of a given material as in the case of tensile testing. It has been found also that this method of testing can be used to good advantage as a control procedure in the factory.

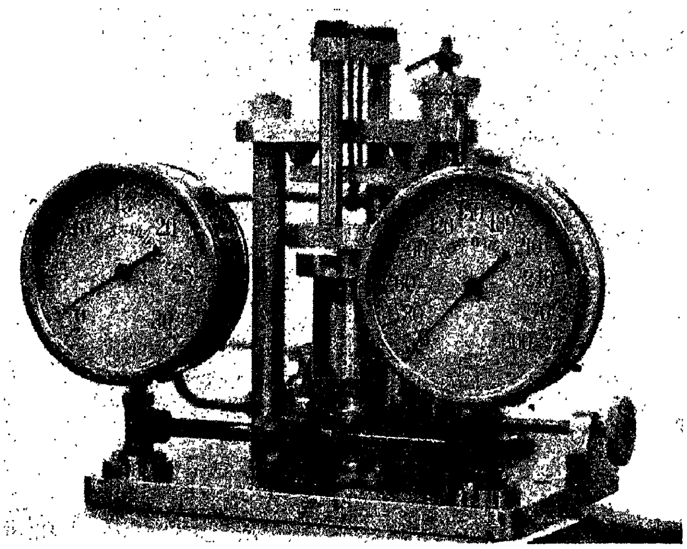
Results of a series of cross-bending tests made on various types of porcelain with the machine shown in the accompanying illustrations are given in Table I. As may be noted, the strain cable on the testing machine applies load to the center of the test bar in such a way that the distribution of stress across the diameter of the bar is uniform. Round test pieces ⅜ in. in diameter and 3 in. long were used.

As Table I shows, the resistance of the material to heat shock also was determined. This was done by heating the small test pieces to the temperatures indicated, and quenching them in water at room temperature. The change in strength after such treatment is an indication of the value of the material's resistance to heat shock regardless of the method of manufacture. It is interesting to note that the modulus of rupture for the various samples of American porcelain tested gave a maximum deviation of only three per cent from the average. These results clearly demonstrate also that the improvement in properties resulting from firing at temperature much higher than encountered in American practise is not so great as might be expected, nor at all commensurate with the higher firing cost involved.

High-strength compositions for somewhat stronger insulators are possible, however. In this connection it must be remembered that the economics of the situation keep the industry within fairly narrow limits. The increase in cost attributable to the use of more expensive materials is relatively slight; the real expense comes in the fuel used to obtain the higher firing temperatures required for such compositions; which at

---

From "Electrical Porcelain," (No. 30-163) presented at the A. I. E. E. Middle Eastern District meeting, Philadelphia, Pa., Oct. 13-15, 1930.



Front view of porcelain tester showing test sample in place and method of obtaining evenly distributed strain

present is about 40 per cent of the total manufacturing cost.

It may be noted from Table I that several materials show greater strength unglazed than glazed. This indicates that these glazes have a coefficient of expansion widely different from that of the body and place the two under differential stress. A properly fitting glaze should increase the mechanical strength of the porcelain by sealing the exposed contacts between the grains of the structure.

TABLE I—MODULUS OF RUPTURE OF CERAMIC MATERIALS, INCLUDING TESTS ON QUENCHED SAMPLES

	Lb. per sq. inch			
		Quenched from		
	Not quenched	200 deg. cent.	300 deg. cent.	400 deg. cent.
Standard American porcelain				
Glazed—regular glaze coating	14,805	12,990	4,394	4,060
" thin glaze coating	13,357	11,350	4,443	3,816
" very thin glaze coating	12,327	11,350	4,804	4,069
Unglazed	12,310	5,472	4,541	4,084
German Porcelain A				
Glazed	15,594	16,225	12,110	3,466
Unglazed	14,047	13,900	4,724	4,843
German Porcelain B				
Glazed	14,004	14,400	3,184	3,305
Unglazed	12,327	11,048	3,952	3,509
German Porcelain C				
Glazed	10,797	5,012	3,730	3,571
Unglazed	12,786	10,465	4,291	3,853
Steatite (plastic process)				
Glazed	20,086	14,550	All shattered	
Unglazed	15,667	7,266	5,720	4,166
Melalith				
Glazed	11,236	All shattered		
Unglazed	14,810	5,204	4,311	3,327
Sillimanit				
Glazed	12,926	13,231	3,510	3,125
Unglazed	11,135	4,480	3,382	3,440
American Chemical Stoneware				
Glazed	8,922	7,670	3,390	2,920
Unglazed	7,980	6,013	3,305	2,655

In some cases the glaze is detrimental to resistance of thermal shock; for upon quenching, it not only weakens, but shatters badly. The question of glaze fit has been studied from various angles and its importance has been demonstrated in many different ways.

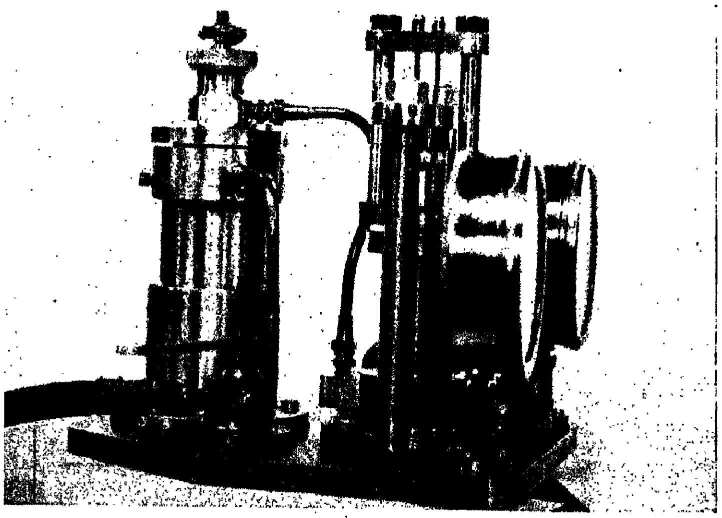
In regard to the uniformity of composition of porcelain now being manufactured, it is sufficient to say that recent chemical analyses reveal only slight differences in these compositions. The best of them is not the highest in silica content, nor the lowest in alkali content (therefore lowest in feldspar); and it has only an average clay content as judged from the alumina present.

The manufacturer of porcelain undoubtedly will find that he can make the greatest strides towards producing a reliable product by keeping his processes as simple as possible and by developing rational methods of control for them. This, unfortunately has not been done extensively, but a striving for uniformity in this manner is undoubtedly of greater benefit to the industry than the use of peculiar processes of unproved or questionable scientific value.

Checking raw materials, fineness of grinding within the plant, consistencies, forming and drying operations and particularly firing processes should be under close control and observation at all times. A full understanding of the effects of varying cooling rates at the various stages of the cooling cycle is also necessary for the most effective operation.

For a long time the x-ray has been looked upon rather hopefully as a possible means of accomplishing routine inspection of porcelain for flaws. But unfortunately the length of time required for an exposure prevents it being used as anything but a laboratory tool.

The assembly of the fired porcelain into pin-type or suspension insulators is as important, or perhaps even more important, than the production of the porcelain



Side view of porcelain tester

itself, for with faulty design or assembly, the best insulating medium may give only inferior mechanical strength and insulating value.

Cement used in the assembly of the insulators must be controlled for uniformity as closely as the clays used in making the porcelain. Temperature variations affect the viscosity and resulting thickness of plastic coatings applied to sand bands and other parts incorporated in the assemblies.

Within the last few years the design of the various parts of these assemblies has been studied systematically from purely theoretical, mechanical, and mathematical standpoints. Photoelastic studies by which accurate determination of stress concentrations in these assemblies have been made have assisted materially in determining the best types of design. The use of other methods of stress studies in three-dimensional models has now been developed. These studies have paved the way for a distinct advance in insulator design, the benefits of which have already been made apparent.

◆ ◆ ◆

Hydrogen Cooling for Turbine-Generators

With the development of efficient sealing glands and reliable control apparatus the already proved advantages of hydrogen gas as a cooling medium for rotating electrical machinery appear to be readily available for large generators. Actual operating experiences with a 7,500-kv-a. unit are outlined here.

By M. D. Ross
Associate A. I. E. E.
Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

LARGE TURBINE-GENERATORS of today are appreciably smaller, more reliable, and more efficient than the corresponding machine of even five years ago. These improvements are traceable largely to such factors as better methods of ventilation, stronger rotor steels, lower loss in armature laminations, and improved methods of insulating rotor windings. However, in recent designs for the larger machines using present materials, methods of construction, and accepted performance characteristics, there are indications of a close approach to the limits of possible ratings. Therefore, it is believed that any marked further advancement in performance or maximum size probably will result only from radical changes in fundamental design.

Consequently, a great deal of research has been carried out recently in connection with the cooling of rotating machinery by means of gases other than air. A survey of available gases shows that because of its low density (about 7 per cent that of air) and high heat-transfer characteristics with forced convention, hydrogen is the gas most suitable for this purpose. Furthermore, since windage losses vary approximately in proportion to the density of the cooling medium, such losses through the use of hydrogen can be reduced to a negligible figure. Some of the advantages of hydrogen as a cooling medium for rotating electrical machinery are summarized briefly:

1. Windage losses, which may be as much as 40 or 45 per cent of the total losses, are reduced to about 10 per cent of their value in air.
2. For a given amount of active material the rating of a generator with hydrogen cooling would be about 25 per cent greater.
3. In an atmosphere of hydrogen corona has little, if any, effect on insulation. Insulation operating in hydrogen therefore should have a much longer life than in air.
4. Because of the absence of oxygen, fires in th generator cannot occur.
5. Smaller gas coolers and less cooling water are required than with air cooling.

SHAFT SEALS FOR TURBINE GENERATORS

One of the most important developments in connection with hydrogen cooling for turbine-generators has been the design of sealing glands to prevent gas leakage around the shafts where it emerges from the gas-tight enclosure. Experimental work started in 1925 and which covered various methods revealed that a liquid seal employing oil as the sealing medium was best adapted for use with the relatively high shaft speeds involved. Data showed also that a suitable supply of oil under pressure could be obtained from the turbine lubrication system.

An experimental sealing gland was built in 1926 to determine the performance that could be expected in seals for large generators; details of this gland are shown in section, in Fig. 1. Oil under pressure is fed into a groove in the center of the seal and flows both ways over the shaft; the oil film thus formed between the shaft and the seal casting is sufficient to stop the flow of gas at that point provided the oil pressure is higher than the pressure of the gas in the machine. The flow of oil is throttled to a minimum by three

---

From "The Application of Hydrogen Cooling to Turbine-Generators," (No. 30-177) presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

small brass rings fitted closely into grooves in the seal casting and held lightly against the shaft by coil springs.

Tests made on this gland showed that the loss of hydrogen through the seal was very small and that no special detraining tanks were required to separate the hydrogen from the oil before returning the oil to the main system. It was found however that a certain amount of air was being carried into the gas enclosure by the gland oil. Therefore from time to time a quantity of hydrogen gas would have to be added to the mixture to maintain a suitable purity within the machine. Tests showed that for the largest machines this quantity should not exceed 200 cu. ft. per day.

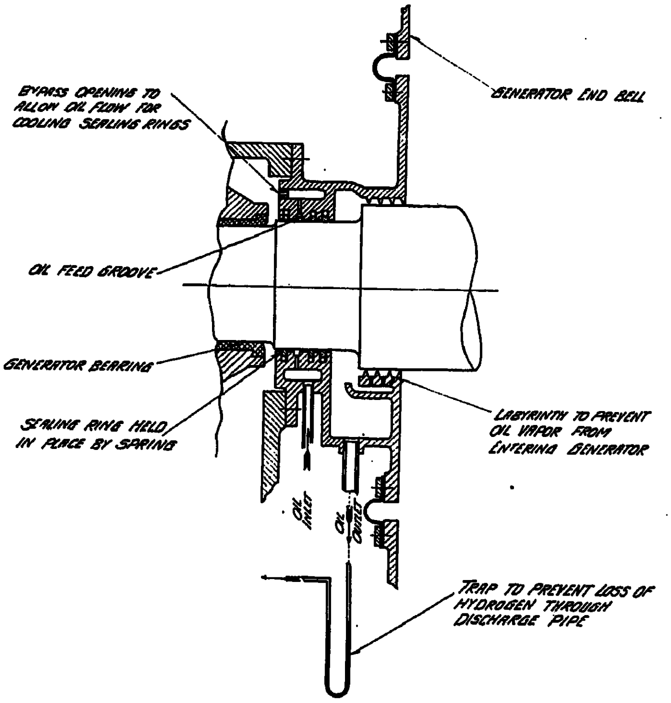

BYPASS OPENING TO ALLOW OIL FLOW FOR COOLING SEALING RINGS
GENERATOR END BELL
OIL FEED GROOVE
GENERATOR BEARING
SEALING RING HELD IN PLACE BY SPRING
LABYRINTH TO PREVENT OIL VAPOR FROM ENTERING GENERATOR
OIL INLET
OIL OUTLET
TRAP TO PREVENT LOSS OF HYDROGEN THROUGH DISCHARGE PIPE

Fig. 1. Sectional elevation revealing details of hydrogen sealing gland

EXPERIMENTAL TURBINE GENERATORS BUILT

In 1928 a 7,500-kv-a., 3,600-rev. per min. generator designed for hydrogen cooling and incorporating the sealing gland just described was built and tested. The frame was constructed along standard lines with certain modifications to make it gas tight. Tests on this machine indicated that in order to obtain minimum gas leakage, frame structures for hydrogen cooling would have to be quite different from the air-cooled designs.

Accordingly early in 1930 a second machine of the same capacity and speed was built and put on test (see Fig. 2). The generator frame was fabricated from steel plate with a minimum length of bolted joints. Active parts of the generator were the same as the standard air-cooled machine parts, and no particular effort was made to design the machine to obtain maximum results with hydrogen cooling. Two sealing glands of the type described were provided, rigidly attached to the bearings, and connected to the end-bells by flexible diaphragms.

Two Griscom-Russell finned-tube gas coolers were built into the generator frame *above* the armature core. To simplify construction and to make the cooler sections more accessible for cleaning straight-tube coolers were adopted and since experience with coolers on a large number of machines never had indicated trouble from leakage or fractured tubes no operating hazards were considered involved in placement of the coolers above the generators.

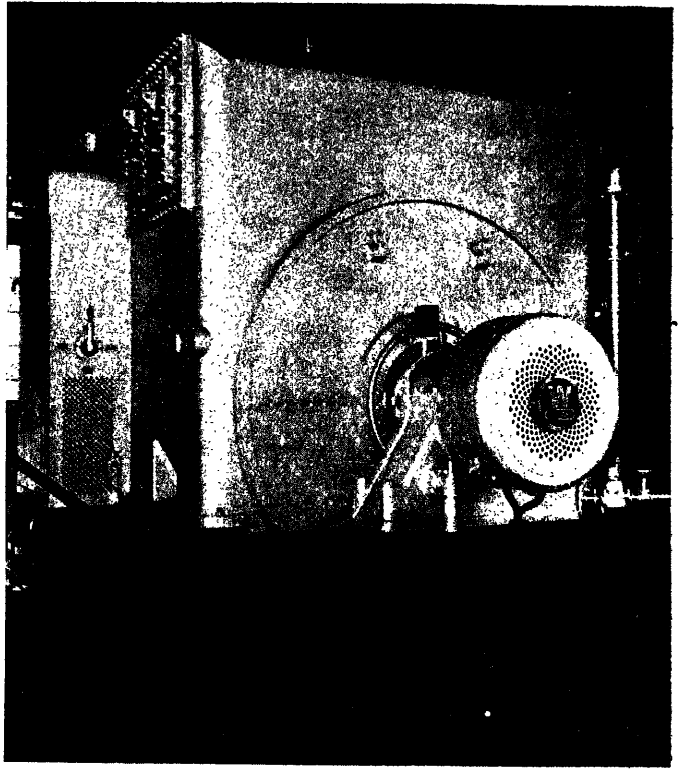


Fig. 2. A 7,500-kv-a. generator with frame and housing designed for hydrogen cooling. Fin-type coolers may be noted above the rotor; control cabinet at the left

Armature leads were brought out through six gas-tight condensers bushings in a flange on the bottom of the generator. Through holes drilled in the shaft field leads were carried to a point outside the bearing where they were connected to the collector rings. Insulating stuffing nuts were provided to keep the gas from leaking around the field leads.

A special system for controlling the gas in the machine was developed, as simple and sturdy in design as possible so that its operation would be readily understood by the average station attendant. In Fig. 2 the control panel is shown bolted to the side of the generator. Principal functions of this apparatus include:

1. Maintenance of gas pressure in the machine at somewhat above atmospheric, to avoid leakage of air into the machine.
2. Warning to the operator when the purity of the gas is too low, so that more hydrogen may be added to bring it up to the proper value.

Electrically-operated intake and relief valves controlled by pressure-operated switches maintained the pressure in the machine at the proper level. A small motor-driven fan running at constant speed drew a small quantity of gas from the generator and before returning it to the machine forced it through an orifice. The pressure difference between the two sides of the orifice is proportional to the density of the gas passing through it. This difference in pressure was registered on a gage mounted on the front of the panel, so that the operator could readily determine the purity of the gas in the machine. Under normal operating conditions, the purity of hydrogen in the machine was maintained at a value greater than 95 per cent which, considering that mixtures of air and hydrogen containing more than 70 per cent hydrogen are non-explosive, allowed a wide factor of safety.

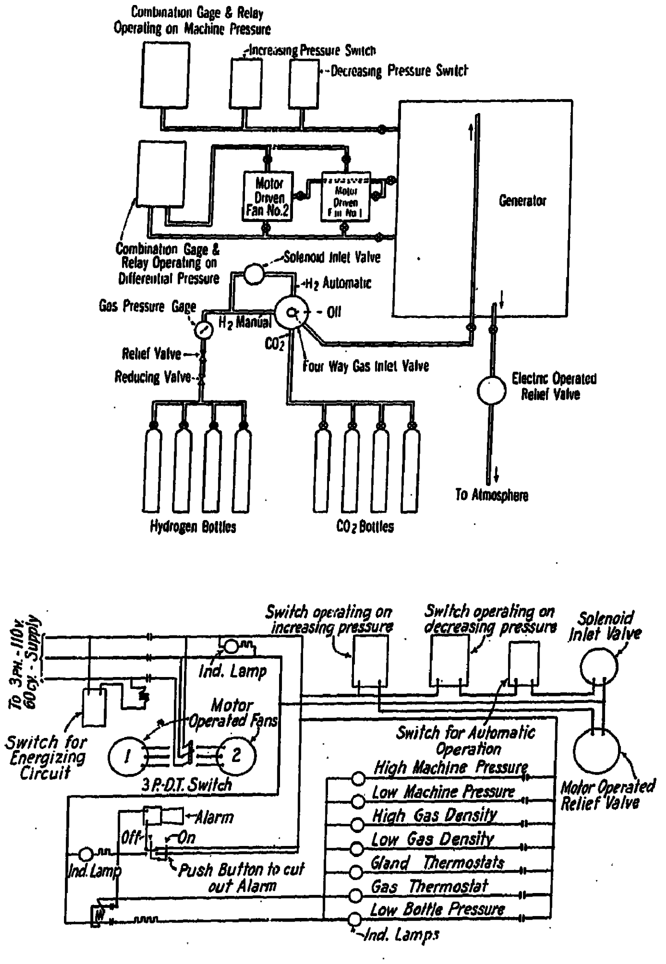


Fig. 3. Piping and wiring diagrams showing hydrogen handling and control methods

Piping required for the gas system is shown schematically in Fig. 3. Fig. 4 shows the wiring diagram for the electrical apparatus used to operate the gas control system. As may be noted, alarms are provided to warn the operator in case of any troubles in the gas system. A supply of carbon dioxide gas is provided with suitable control valves, to take care of removing the air when filling the generator with hydrogen or to remove the hydrogen when scavenging the machine so that explosive mixtures will not be obtained.

EXPERIMENTAL OPERATING DATA

Up to the time of writing this paper the generator now under test has been operating satisfactorily for seven months. No troubles were encountered with the control and sealing gland features and the glands themselves showed no evidence of wear when inspected after intermittent running with no special attention. Whenever the generator was shut down with hydrogen in it the oil pump was kept in operation to maintain the seal at the shafts. Without oil pressure there was some leakage of gas through the sealing glands, but the infiltration of air probably would be very slow.

Comparative temperature rises of the stator and rotor of this generator with air and with hydrogen cooling are given in Fig. 4. With hydrogen cooling, the machine could be rated at 9,375 kv-a., 0.8 power factor. The windage loss with hydrogen was 7 kw. as against 73 kw. with air. This represents an improvement in efficiency of 1.1 per cent at a 6,000-kw., 0.8-power-factor load. The cooling water required for 9,375 kv-a., 0.8 power factor with hydrogen cooling was approximately 40 gal per min., as compared to 80 gal. per min. with air cooling and only a 7,500-kv-a., 0.8-power-factor load.

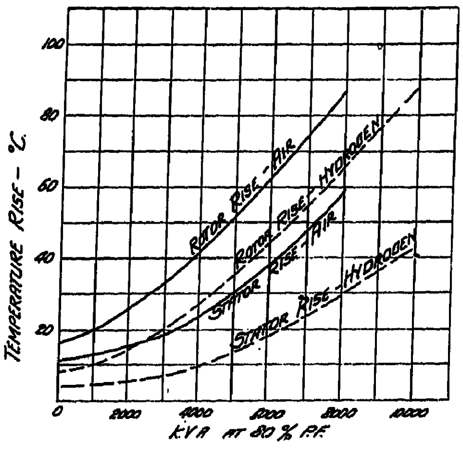


Fig. 4. Operating characteristics of a 7,500-kv-a. machine operating in air and in hydrogen

Desirability of Adopting Hydrogen Cooling

The first question usually raised in connection with hydrogen cooling is: what will happen in case of an explosion? With the worst mixture of air and hydrogen, the explosion pressure will be from 50 to 75 lb. per sq. in., depending upon the size and shape of the gas chambers in the generator. If the frame is provided with a number of diaphrams which will blow out at relatively low pressures, the pressures developed will be lower than the foregoing values. Operating hazards with a hydrogen-cooled generator on a control system such as that just described probably is no greater than those involved in operating other types of station control equipment; therefore it is questionable as to whether frame structures for hydrogen-cooled generators need be made explosion-proof. No attempt was made to design the two 7,500-kv-a. generators described in this article to withstand explosion pressures; however, if an explosion-proof frame be considered necessary it could be built with some increase in cost over that of the lighter frame designed on the basis of gas tightness only.

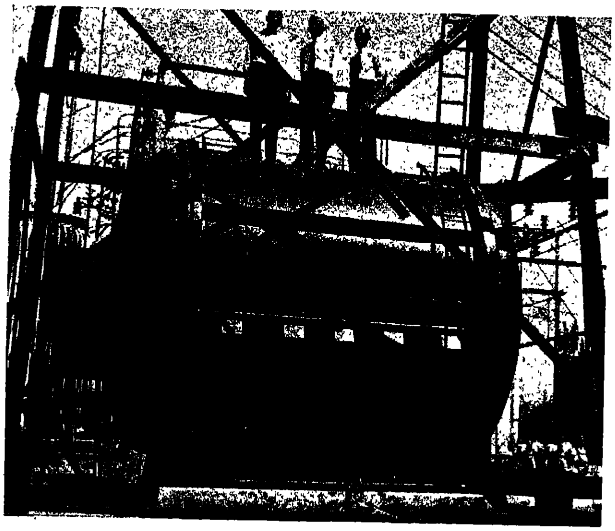


Fig. 5. A 15,000-kv-a., 750-rev. per min., 50-cycle, hydrogen-cooled, synchronous condenser being installed by the Southern California Edison Company, Ltd.

Several hydrogen-cooled synchronous condensers are now in service and as indicated by the number of this type of machine now on order are growing in popularity. As the synchronous condenser does not have to be mechanically coupled with any other apparatus, it can be enclosed readily in a gas-tight casing with provision for cooling the hydrogen gas and recirculating it. The problem so far as hydrogen-cooled turbine-generators are concerned is somewhat different as in order to couple it to the turbine the generator shaft must be brought out through the gas-tight enclosure. It is desirable also to bring the collector-end shaft outside the enclosure to permit work on the brushes while the machine is in operation. This is an important feature in turbine-generators which are sometimes run six months or more at a time without shut-down. However, with the development of sealing glands and control apparatus to the point where their operation can be relied upon in continuous service, there is no apparent reason why hydrogen cooling should not be adopted for large turbine-generators.

Preliminary studies indicate that hydrogen cooling would be desirable in ratings of from 30,000 kw. up. In comparison with the cost of the generator, additional cost of gas-tight enclosures and the control equipment would be relatively small, and the saving in losses would justify the slight additional complication due to this method of cooling. The cost of hydrogen gas should not exceed two dollars per day for the largest generators—a negligible figure when compared to savings in generator losses. As the turbine floor attendant can take care of the gas control equipment the labor cost for operating the generator would be no greater than for an air-cooled generator and while the hydrogen-cooled design would be somewhat harder to take apart than an air-cooled design, the absence of dirt and corona effects in the machine would probably more than balance that point in estimating the cost of maintenance. With built-in gas coolers, as in the hydrogen-cooled machine, considerable space under the generator would be available for removal of condenser tubes and for auxiliary apparatus which is not available with air coolers located below the generator.

The following example indicates the savings in operating expenses with hydrogen cooling, and the possible capitalization of these savings:

Assume:

1. A generator of 100,000-kw. rating, at 1,800 rev. per min.
2. Reduction in windage losses with hydrogen cooling to be 600 kw.
3. Operating time per year to be 7,000 hr.
4. Value of power at the bus to be 0.4 cent per kw-hr.

Savings can be evaluated as follows:

Value of power at bus (4,200,000 kw-hr.).....	$ 16,800
Less cost of gas at $2 per day and cost of hydrogen and carbon dioxide for three fillings after shut-down...............	1,100
Net saving per year with hydrogen cooling...	$ 15,700
Capitalization of savings at 15 per cent......	$105,000

While the first machines built will cost probably somewhat more than the equivalent air-cooled machines, it is hoped that eventually the hydrogen-cooled design will be produced for the same cost per kv-a. as the air-cooled design.

President Lee *answers* Governor Pinchot

AS A MATTER OF RECORD the full text of a telegram received at Institute headquarters from Governor Gifford Pinchot of Pennsylvania and the full text of President Lee's reply thereto are set forth herewith.

GOVERNOR PINCHOT'S TELEGRAM

January 28, 1931

My dear Mr. Lee:

The Annual Meeting of the American Institute of Electrical Engineers now in session is the occasion for my bringing to your attention a matter of grave social import which seemingly calls for action by an association of engineers specializing in the electrical field. The American system of regulation of the electrical industry by state commissions is threatened. The failure of our commissions adequately to control electric service furnished to the homes and stores, and farms, of the country, has occasioned widespread public discontent.

While these consumer groups use not more than one-quarter of the electricity generated they supply approximately sixty per cent of the industry's revenues—and that the most stable portion, as experience in the present depression demonstrates.

One of the principal difficulties in regulating domestic, commercial, and rural electric service is the entire absence of any literature on distribution engineering—a phase of expense peculiar to the service to small consumers and alleged to account for our high domestic, commercial, and rural rates.

Our public service commissions have at their disposal a wealth of information about the generation of electricity and about its transmission. But about distribution, which covers the ultimate disposition of transmitted current to our homes, stores, and farms, there is not a word. The subject has never been discussed before any engineering society—local or national. The secretary of your Institute is authority for the statement that the proceedings of your own organization do not mention distribution.*

Over twenty billion kilowatt hours of electricity were sold to these three classes of small consumers—homes, stores, and farms—in 1929 at an average rate of over $6\frac{1}{2}$ cents per kw-hr. Subtracting an ample allowance for the generation and transmission of the current it will be seen that revenues from this distribution amounts to upwards of $900,000,000 annually out of the industry's total receipts of about $2,000,000,000.

It is most unfortunate that this vast field of engineering and social outlay remains uncovered by an appropriate literature. It would be of material assistance to those of us who are charged by the people with the responsibility for effective and confidence inspiring regulation to have the cooperation of your organization in providing us with the results of technical discussion of distribution engineering, including distribution costs. With the importance and social significance of the matter brought to your attention, I shall hope to see a start made on a literature of distribution comparable to those of generation and transmission.

Yours very sincerely
Signed GIFFORD PINCHOT

PRESIDENT LEE'S LETTER

February 7, 1931

My dear Governor:

Replying to your night letter of the 28th ultimo and with further reference to my acknowledgment of February 3: Your message claims the entire absence of any literature on distribution engineering and also states that our public service commissions have at their disposal a wealth of information about the generation and transmission of electricity, but about distribution, not a word.

For years past, the American Institute of Electrical Engineers has had an active committee on power transmission and distribution, this being one of the standing technical committees of our organization. A large number of papers and discussions upon distribution engineering has been presented at meetings of the Institute and these have been published in our monthly Journal and quarterly Transactions, and are available to the public.

In Pennsylvania, as in most other States, every electric public utility company is required to report in considerable detail on its plant and operations, including for its distribution system its costs under the following headings:

Land
Leaseholds
Rights-of-way
Distribution system structures
Poles and fixtures
Overhead conductors
Overhead transformers
Overhead transformer installations
Overhead services
Underground conduits
Underground conductors
Underground transformers
Underground transformer installations
Underground services
Meters and meter installations

Therefore, after considering your telegram, I fear that you have been misinformed on this particular subject.

The technical problems of distribution are constantly under discussion by our organization and this will naturally continue. These problems involve such references to costs as may be appropriate to an understanding of the engineering aspects of particular problems, but such discussions do not deal with overall costs of service, whether they relate to electric power, telephone, telegraph, railway, or other utilities. Costs of distribution necessarily include taxes, cost of financing, and many commercial and other aspects, often greatly influenced by local conditions, which fall essentially outside the engineering field; hence, discussions of such costs belong more properly to the activities of other organizations.

Our Institute is a professional engineering society, the objects of which, as defined in our constitution, are "the advancement of the theory and practise of electrical engineering and of the allied arts and sciences and the maintenance of a high professional standing among its members."

One of the principal methods of attaining these objects is by holding national, district, and local meetings for the presentation and discussion of electrical engineering and related subjects. Any member may submit for presentation and publication a paper upon any subject within the field of electrical engineering. The code of our technical program committee provides that "to be acceptable a paper should present information which adds definitely to the theoretical or practical knowledge of electrical engineering," and this code also specifies certain groups of subjects which are not regarded as suitable for Institute presentation, including the following: "As abstract propositions not directly connected with electrical engineering,—purely economic and allied studies such as rate making, project financing, obsolescence, depreciation, statistical methods, utility regulation, factory organization, etc."

Respectfully yours,
Signed W. S. LEE

---

*Editor's Note: Apparently this statement represents a misinterpretation of a reply by the editor of ELECTRICAL ENGINEERING to an inquiry from Mr. Morris L. Cooke of Philadelphia, relating *exclusively* to distribution *costs*. It is a matter of record that more than a dozen papers dealing with various phases of distribution engineering have been published by the Institute within the past two years.

News
Of Institute and Related Activities

Winter Convention's Ten Technical Sessions Each Reported Here Under Separate Heading

Edison Medal Presented to Dr. Conrad

PRESENTATION of the 1930 Edison Medal, highest award of the American Institute of Electrical Engineers, was made Wednesday evening, January 28, 1931, at a special meeting held in connection with the Institute's winter convention, to Dr. Frank Conrad of Pittsburgh, for his contributions to radio broadcasting and short-wave radio transmission. Dr. Dugald C. Jackson, past-president of the Institute, chairman of the Edison Medal Committee, and one of those who assisted in the founding of the award in 1904, briefly sketched the origin and history of the medal. The medal presentation was made by W. S. Lee, president of the Institute, following an inspirational address by Professor Charles F. Scott, past-president of the Institute, and Edison medalist in 1929. An abridgment of Dr. Scott's address follows:

Address of Dr. Chas. F. Scott

"This twentieth award of the Edison Medal is unique, in that the man so honored left school when he was but sixteen—a year before he might have entered high school—whereas all prior recipients of the Edison Medal have attended an institution of higher learning. On leaving school Frank Conrad got a job running a drill press making parts for Shallenberger ampere-hour meters; now, after forty years, this self-made scientist and engineer receives the distinguished service medal of his profession for his important contributions to its advancement.

"Just what differentiated this particular operator of an ordinary machine tool from scores of others in the same shop? What enabled this grade-school lad to meet successfully the competition of thousands of engineering graduates? And this in an age assailed by critics as reducing men to dull automatons! Many of his achievements have determined the course of electrical practise today; untold numbers of them have had an important influence. In the vernacular, this man has pulled himself up by his own boot straps. But what manner of man is this who although little-known to the public has made such a record? And what kind of straps, and what kind of a pull? To answer these questions it is necessary only to trace the man's life and work.

CONRAD'S EARLY LIFE

"What were the antecedents of the . . . boy, useful, ingenious, ambitious? Conrad's father was a railroad man,—a mechanic, a millwright having to do with upkeep and repair of machinery, steam engines and pumps, heating plant, lighting, batteries for telephone, and signals. He had sound ideas about developing boys for he saw to it that Conrad had something to do when not at school by providing him with simple tools and a place to use them—equipment . . . augmented by contributions from the scrap heap of the repair shop.

Facsimile of the face of the Edison Medal, highest A.I.E.E. award, made annually "for meritorious achievement in electrical science, electrical engineering, or the allied arts"

"Conrad learned the door-bell circuit; the ways of connecting battery cells together; he experimented with coils and improvised parts. He was curious about measuring electricity and made his own galvanometers. His mother's father was a civil engineer; Conrad quietly requisitioned his compass, wound a coil to complete a tangent galvanometer and had the satisfaction of a uniformly divided scale.

"Conrad's mother died when he was quite young and he lived sometimes with his father in Pittsburgh, attending the Starrett School, and at other times with his grandparents who lived in Altoona and had a nearby farm . . . But school was perfunctory. Lessons came easily, but the things taught did not excite interest or stimulate investigation and thought. School seemed a waste of time; he wanted to make a steam engine to run his toys or a galvanometer to measure his current. And so the boy brought with him to the laboratory a simple faith in nature's methods which the formal text book did not give . . .

"As co-worker . . . I have known Frank Conrad for many years . . . We met frequently during the twenty years we were together . . . in the same works; . . . in the subsequent twenty years . . . our long-time friendship has deepened . . . Accounts of his boyhood traits, of his development and methods, and of his engineering achievements, are not independent chapters but are interrelated in a single, progressive story.

CONSTRUCTIVE INQUISITIVENESS

"Soon after Conrad began work on the drill press a significant incident occurred; he observed others who were working on arc lamps; he realized their difficulties and devised improvements. These are important steps—observation, analysis, invention . . . Subsequently he found out by trial why volts should not be measured with an ammeter. He made the personal acquaintance of choke coils, transformers, and condensers, and tried about everything he could think of with circuits and apparatus . . . Also he was engaged in studying algebra and geometry by himself . . .

. . . "H. P. Davis and Conrad worked together on the arc lamp, trying to induce it to give a reasonable performance on alternating circuits. The early induction-indicating instruments and watthour meter were large and expensive and although these lay outside of their official province, they undertook to study them as a sort of extra-curriculum activity. They developed a simple form of long-scale indicating instrument which is still used.

"Conrad then sought improvement of the watthour meter and . . . by a happy combination of painstaking study and intelligent cut-and-try . . . he evolved in 1897 the type of magnetic circuit which still is used in the "round-type" watthour meter.

Typical Radio Amateur

"The radio story is fascinating; it began in a simple, indirect way about 1914. A fellow engineer boasted a high-grade watch; . . . . in lunch-table discussion Conrad entered his mongrel timepiece in competition. Realizing that his watch would make a better showing if reset nightly by Arlington time signals he undertook to make a radio receiver, and presently had a crystal device by which he heard ticks. Uncertain whether it was Arlington, he improved his receiver, learned the Morse code, and found the ticks were the station call of a nearby amateur. Presently the Arlington signals made his watch the winner.

"Radio interest continued. His company took part in war activities and he was assigned radio problems and was in consulation in Washington, D. C. Among other achievements was a 1,000-cycle, 200-volt self-exciting generator for airplanes, weighing eleven pounds (much less than the French equivalent), encased with the radio equipment, and driven by a propeller. This was unique in being an American radio device which saw actual war service.

"Following the war, . . . Conrad had an experimental station at his home. One problem was to perfect apparatus for communication between the company's factories in different states. In these local tests his conversations and phonograph music were heard by neighboring amateurs; they liked music better than Morse code; they found the source and asked for more . . . The enterprise grew . . . Presently the studio was moved from garage to house and there were musical groups who were the original radio artists—predecessors of Damrosch and Amos 'n Andy . . . From neighborhood broadcasting came national broadcasting.

Genius

"Genius sometimes consists in selecting the thing which though simple is worth while. Among the innumerable wireless amateurs there was one who produced something different; one who attracted and interested others, and at some personal inconvenience contributed to their satisfaction and enjoyment . . . By painstaking observation and investigation in a discarded field Conrad discovered the characteristics of the short wave for extra long distance transmission and has made radio communication and broadcasting world-wide.

"In recounting these achievements it has been the aim to indicate how the subjects were taken up and how they were developed. Scores of other achievements might be mentioned covering methods of operation, pieces of apparatus, . . . grenades, and other war devices, and other items covered by some three hundred patents.

"Conrad's genius has had a propitious environment; the traditional inventor in the attic suffers for resources and sympathetic understanding; the modern counterpart is the organized laboratory force for industrial research.

DR. FRANK CONRAD

Edison Medalist for 1930 who received the award "for his contribution to radio broadcasting and short-wave radio transmission"

An Individualist

"Primarily, Frank Conrad is an individualist. While cooperative he has not surrounded himself with a corps of assistants. He liked to work in his little shop at home and out of his hobbies and his home work have come some of his notable achievements.

"For many years Frank Conrad's official title has been assistant chief engineer of his company (Westinghouse). A few years ago he received the honorary degree of Doctor of Science from the University of Pittsburgh. The propriety of bestowing such a degree upon one who had no other degree was questioned and met by the reasoning: Granting that his career and achievements would have merited the proposed distinction had he an E. E. degree, was it not more creditable to have made such a record without it?"

Dr. Conrad Responds

After receiving the medal from the hands of President Lee and expressing deep appreciation, Dr. Conrad responded as follows, in part:

"Our present civilization can be said to be a product of comparatively few developments. The important ones which may be mentioned in the order in which they came into the world are, (1) printing, (2) the railroad, (3) the telephone, (4) the automobile, and (5) radio. Each of these has been an influence in molding the lives of people and has changed the destinies of nations.

"From early ages, the human race knew the need of implements to further their gregarious instinct. At first, man depended on muscular effort to travel and transport his goods on land; he early developed the art of water transportation from one land to another. Mechanical developments made the railroad possible and brought about mass movement. Then the automobile came as a more individualized form of transport. Printing, the telegraph, and the telephone made possible the direct exchange of ideas without the necessity of actual physical nearness. All of this has made possible our civilization wherein the individual may have the benefit of the sum total of the knowledge and products of his fellow beings.

Broadcasting Launched Fully Developed

"The arts mentioned, with the exception of radio, are not new to this age, but their usefulness has been made effective by the development of science, the uses and development going hand in hand. Radio broadcasting is distinctive in that it was scarcely visualized before the present century, but became a possibility from the developments of present day science. It has the unique distinction of having been launched as a fully developed art. In the first year of broadcasting we had available all the artifices of the present day. It required no new conceptions to make possible its success. We have made advances in technique but they have been of a comparatively minor nature . . .

"One of the factors which made it possible for science to have ready nearly all the tools required for an entirely new art was the World War. Before the war, radio was considered as a possible rival of the telephone or telegraph, and its apparent field of greatest use was in communication from ship to shore, vessel to vessel, or with isolated spots. The desirability of communication between ships for even limited distances served as an impetus to the development of devices which would thus enable a ship in distress to call for help. The apparatus as developed before the war period effectively served this purpose although it would not make possible the use to which radio is put today. The military necessities of war times not only furnished the incentive for a further development, but what is even more important, furnished the financial support necessary for this work.

"At the close of the war we found ourselves in possession of the products of many research agencies, although there was no apparent use to which these products could be put. The tools were there but there was, so far as the world could see, no work for them to do. I personally experienced this situation in that I had facilities and equipment to carry on this art of radio communication, but no incentive to do it other than the natural fascination of working with a new tool. It is probable that by demonstrating to some of my friends the possibilities of this new instrumentality, we awakened to the fact that radio's field of usefulness was not between any two restricted points, but instead was over the widest possible area. Radio broadcasting, a new art, so came into being. . . .

"The progress of any development usually is one of slow evolution. The railroad at first was an exceedingly impractical and apparently impossible venture. . . . The telephone instruments which Bell exhibited at the Centennial Exposition in 1876 were workable devices and compared favorably with the instruments used for many years afterwards. Except for refinements that came in later years, Bell's equipment was probably the great major step in this development until the telephone borrowed from radio the vacuum tube, which device has made possible the intricate telephone systems of today.

What of Specialization?

"We should, of course, expect that any new development will progress relatively more rapidly than those that came in an earlier day, because each new development has the advantage of utilizing an accumulated storage of knowledge. We might ask: Is this store becoming greater than one individual mind can assimilate? An affirmative answer might be construed from the present tendency to specialization, but I hope we shall not specialize so thoroughly that some change in our environment will subject us to the fate of the highly specialized prehistoric animals who could not survive a change in the conditions suited to their particular existence. We, of course, may find the necessity of extreme specialization in present day sciences is not so real after all. . . "

◆

Telegraphic Speed Reaches 2,500 Words per Minute

Telegraphy is the first commercial application of electricity on record. Unlike a great many of these early developments which long since have been discarded, telegraphy still is in the course of active development. During the first twenty years this development progressed to a remarkable degree—so far, in fact, that no further advance in the art was brought out until the comparatively recent, extensive application of the vacuum tube. It is a tribute to the engineers of the time of Lord Kelvin that their work was carried out upon such a firm foundation that no further advances were made for such a long period. Five papers presented at the 1931 winter convention emphasized the efforts being put forth to increase speed and improve accuracy.

High-Speed Cables

A joint paper by J. W. Milnor and G. A. Randall, Western Union Telegraph Company, New York, showed some of the design characteristics and operating performances of high-speed ocean cables. It was demonstrated that now a transmitting speed of 1,400 letters per minute, simultaneously in both directions, is practicable; in uni-directional service a speed of 2,500 letters per minute is attainable. Indications are that the ultimate speed has not yet been reached, and that high-speed duplex operation is highly desirable, especially in cases where the installation of only one cable has been justified. However, in some cases—for example between America and Japan—the difference in time is such that most of the traffic naturally flows in one direction at a time, and it is better therefore to operate in one direction only in order to take advantage of the higher speed possible when operating that way. Usually where more than one cable is available part of the equipment is operated duodirectionally, and part uni-directionally, depending upon traffic conditions.

Interference

Any consideration of cable operating speeds, however, leads to a consideration of interference. This was shown in the other paper presented by Mr. Milnor. It is known that interference definitely limits the speed at which a cable can be operated. Such interference is caused sometimes by other nearby cables, and sometimes by power or railway systems in the vicinity of the cable terminals. The most troublesome form is that which in origin is chiefly natural, and may be likened to atmospheric disturbances commonly known as static.

The interference from natural causes is greatest at moderate frequencies, decreases with increasing depth of cable, is greatest at low latitudes, and also depends to some extent on cable design and shielding. This type of interference can be controlled to a considerable extent by installing a "sea earth" of the proper length, depending upon the local and economic conditions involved.

Cable Testing

An interesting dissertation was presented by F. B. Bramhall, Western Union Telegraph Company, New York, concerning a unique telegraph testing machine. The machine was shown to have a wide variety of uses, most important of which appears to be the measurement of distortion on telegraph lines, the study of telegraph relay operating characteristics, and the measurement of telegraph line efficiency.

The novel feature of this device is its recording mechanism through which the record is made by electrochemical action between the indicating needle and a chemically treated paper strip. The needle is in continuous contact with the paper but does not make a record until a potential is applied to it.

Private-Wire Service

A paper by W. B. Blanton, Western Union Telegraph Company, New York, dealt with the system now in use for handling messages in telegraph printer installations. This system was developed for the quick answering of calls, which is of extreme importance in high-speed transmission.

It was stated that in the new installation in New York, 1,600 circuits are being handled from 608 operating tables. The system has worked out so well that only a few seconds are required to answer a call, and the total time of completing a message has been almost halved.

R. E. Pierce, American Telephone and Telegraph Company, New York, gave some interesting facts concerning the private-wire telegraph service maintained by the Bell system. (This paper was abstracted, beginning on page 45, of the Jan. 1931 issue of ELECTRICAL ENGINEERING.)

The session was presided over by H. S. Osborne, Transmission Engineer, American Telephone and Telegraph Company, New York, and vice-chairman of the A. I. E. E. committee on communication.

◆

Higher Speeds Aim of Railway Motors

The only evening business session held in connection with the winter convention was devoted to the discussion of single-phase a-c. railway motors. The occasion was a joint meeting of the Institute's transportation committee and the Transportation Group of the New York Section.

Locomotives employing these motors have been in use by the New York, New Haven & Hartford Railroad Company since 1907, and from the standpoints of both operating experiences and maintenance costs are proving quite satisfactory. In an effort to provide for greater loads and higher sustained speeds intensive development work has been carried on in connection with these motors during the past few years. Two papers covering design details and operating characteristics were presented during this session—One by H. C. Jungk, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., and the second jointly by F. A. Pritchard and Felix Konn, both of the General Electric Company, Erie, Pa. A lively discussion followed in which almost every phase of operation with this type of motor was brought up by the numerous railway engineers present.

These two papers appear in abridged form beginning on pages 1009 and 1013 of the December 1931 issue of THE JOURNAL OF THE A. I. E. E.

High Torque vs. High Speed

Mr. Jungk stated that the prime requirements for railway motors are high starting torque and high maximum running speed. The main difficulties in achieving this with the series a-c. motor were found to be in building a motor with sufficient poles to keep the flux per pole small, and still keep the armature diameter small enough to permit the desired running speed.

In Mr. Pritchard and Mr. Konn's presentation, a number of pictures were shown illustrating the structural details of these motors. Here again was emphasized the desirability of keeping the flux per pole small in order to minimize commutation difficulties but in addition was demonstrated how the application of interpoles and compensating windings to these motors also greatly improved commutation.

In addition to the items already mentioned, the following were pointed out:

1. Operating characteristics of single-phase, series, a-c. motors compare favorably with those of series, d-c. motors.
2. Commutator peripheral velocities up to 9,000 ft. per min. now are permissible with the use of the disk-spring construction.
3. Better core materials and more compact brush holders have permitted a large number of poles with small motor diameter.
4. More compact ventilation design now is obtained.
5. The use of roller bearings is an important aid in obtaining high speed.
6. Locomotives now being built with these motors have better operating characteristics at all speeds than do steam locomotives.

It was stated that it now is practical to build locomotives with single-phase series 25-cycle, a-c. motors (in twin) for an axle loading as high as 75,000 lb., and a maximum sustained speed of 90 mi. per hr. There is every reason to believe that should higher loading and increased speed be desired these limits can be exceeded.

◆

From Inductive Interference to Inductive Coordination

Of significance is the fact that an entire session of the winter convention was devoted to a symposium covering the coordination of power and telephone plants. The session was presided over by A. E. Knowlton, associate editor of *Electrical World*, New York, and chairman of the Institute's meetings and papers committee, who said of the session:

> "Actually the symposium has done more than assemble the elements of the problem into a comprehensive perspective, and thus serve as an interpretation for both power and telephone enterprises. It has demonstrated the ability of engineers to solve within their own sphere and that of precise economics, problems which otherwise would have brought into play the incompatible procedures of law. It also has demonstrated that engineers recognize their professional obligations to make available to the populace in general the fruits of technical accomplishment at minimum cost and maximum serviceability. Of all these performances the electrical profession may justly be proud."

Pack and Gherardi Emphasize Harmony

R. F. Pack, vice-president and general manager, Northern States Power Company, Minneapolis, in his introductory remarks, preliminary to the formal presentation of the technical papers, outlined briefly the history of the subject and the activities of the joint general committee of the National Electric Light Association and the Bell Telephone System, which has guided the destiny of this coordination work since 1921. On that initial foundation the various problems involved were approached in the broadest possible spirit of cooperation, bearing in mind the fact that the object to be attained was the removal of friction and the early development of mutually satisfactory construction and operating standards for these two types of utility systems. Mr. Pack said in part:

> "It was recognized also that the public's interest is paramount and that both the power and communication utilities must be able to render their respective services to the public in an economical and efficient manner......... We know now that the foundation stones have thus been well and truly laid. It was not so much what had actually been accomplished that mattered, but that the whole spirit of the relations between the telephone and power interests had been completely changed from one of friction, distrust, suspicion, and even of enmity, to one of confidence, good-will, and a desire on the part of both to cooperate.........I am more and more convinced that this is the sound way to settle such problems and controversies arising between great interests in this country. Courts and regulating authorities approve this method because it promotes harmony and permits them to devote their time and talents to other useful purposes, and because it saves the taxpayers the material expense of costly technical hearings in which the interests of the public are in no way jeopardized."

In adding brief comments, Bancroft Gherardi, vice-president and chief engineer, American Telephone and Telegraph Company, New York, and past-president of the Institute tersely seconded Mr. Pack's remarks by characterizing the original state of affairs as "one in which the two utilities agreed on nothing, whereas now there was entire agreement as to the fundamentals involved, and a willingness to work in harmony" in solving detailed and specific problems. In emphasizing the economic value to all parties concerned including the users of utility services, of working out controversial problems on the basis of sound engineering judgment instead of fighting them out before courts and regulatory commissions, Mr. Gherardi cited the whole situation as illustrative of the broadening scope of the engineer and his work.

Technical Problems Outlined

The "Trend in Telephone and Power Practise as Effecting Coordination," discussed by W. H. Harrison, American Telephone and Telegraph Company, New York, and A. E. Silver, Electric Bond and Share Company, New York, is liberally abstracted elsewhere in this issue.

The "Status of Joint Development and Research on Noise Frequency Induction," was given by H. L. Wills, Georgia Power Company, Atlanta, and O. B. Blackwell, American Telephone and Telegraph Company, New York, who classified the factors contributing to induction in general and to noise frequency induction in particular, discussed methods of control, and outlined some of the further work to be undertaken. A similar dissertation concerning low-frequency induction was presented by R. N. Conwell, Public Service Electric & Gas Company, Newark, N. J., and H. S. Warren, American Telephone and Telegraph Company, New York, who gave a classification of factors responsible for inductive effects and discussed the various factors controlling the magnitude of induced voltages, their frequency of occurrence, and their duration and effect. Types of protective measures also were discussed at some length.

J. C. Martin, Middle West Utilities Company, Chicago, and H. L. Huber, American Telephone and Telegraph Company, New York, discussed the "Status of Cooperative Work on Joint Use of Poles," pointing out good and bad construction practises. (This paper is abstracted elsewhere in this issue.)

◆

Industrial Subjects Attract Institute Attention

Electron tubes, automatic regulators, electrical distribution systems and special types of synchronous motors were included in the discussions presented during a winter convention session devoted to industrial power applications of electrical equipment.

High-Torque Synchronous Motors

A special "Synchronous Motor with Phase-Connected Damper Winding As a Drive for High-Torque Loads," was described by M. A. Hyde, Jr., Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. This particular type of motor was described as having been designed to meet industrial requirements for low-speed synchronous motors such as are used in the drive of grinding machinery in the cement and mining industries. This type of motor is capable of developing extremely high starting and pull-out torque although the results obtained are bound up to an unusual extent in the control equipment which of necessity is somewhat more complicated than with the ordinary synchronous motor.

Some of the problems met in the design and application of synchronous motors to meet special industrial requirements were discussed by D. W. McLenegan and A. G. Ferriss, of the General Electric Company, Schenectady, N. Y. They presented the conclusions that the design characteristics of a normal type of synchronous motor best adapted for steady-load operation should include: (1) separate d-c. excitation, (2) internal revolving field, (3) laminated salient-field poles, (4) air-gap equal to from 1.5 to 2.0 per cent of the pole pitch, (5) amortisseur winding section of sufficient heat capacity to enable the motor to start its load safely, and (6) open armature slots somewhat fewer in number than those of an equivalent induction motor. They outlined methods whereby without abandoning this basic form the electric design of a synchronous motor may be so proportioned as to meet the characteristics required for many different exacting industrial applications.

Industrial Control and Power Distribution

J. H. Ashbaugh, Westinghouse Electric & Manufacturing Company, East Pittsburgh, outlined some of the many industrial operations in which the application of automatic regulators of one kind or another could be made advantageous. He explained the fundamental theory of all regulators and pointed out that any one regulator has a wide range of applications possible, stating as an example that a voltage regulator could be used just as well as a speed regulator or a current regulator. Mr. Ashbaugh asserted that one of the greatest needs was for a fully satisfactory and dependable speed regulator, and described a newly developed carbon-pile device developed for this service.

In discussing "Electrical Distribution Systems for Industrial Plants," Walter J. McClain, electrical engineer with Louis T. Klauder, consulting engineer, Philadelphia, outlined a method of compiling distribution problems and by analyzing these, determining a solution embodying general requirements suitable for an electrical system serving industrial plants. The scope of his consideration included everything from the source of power supplied to the power-consuming devices.

W. R. King, General Electric Company Schenectady, in his paper "Electron Tubes in Industry," gave an illuminating index to some of the rapidly increasing applications of various electron tubes. He touched briefly upon the theory and characteristics of photoelectric tubes and their application, discussed briefly the theory and application of the "pliotron," and discussed at some length the theory and application of the thyratron.

C. H. Drake, general engineer, Westinghouse Electric & Manufacturing Company, and chairman of the A. I. E. E. general power applications committee, swung the gavel during this session.

◆

Traveling Waves and Lightning Effects Studied

In a winter convention session devoted to some of the problems incident to electric power transmission, two general subjects were discussed in five papers: (1) traveling waves on transmission systems and (2) lightning investigations of one character or another. The session was presided over by P. H. Chase, chief engineer of the Philadelphia Electric Company, and chairman of the Institute's transmission and distribution committee.

Continuing an extended investigation, L. V. Bewley, General Electric Company, Pittsfield, Mass., discussed further his investigation and calculations of "Traveling Waves on Transmission Systems." In the current paper Mr. Bewley presented the theory of traveling waves on multi-conductor systems and compiled a brief compendium on the general subject of traveling waves on transmission systems. The origin, shape, and general characteristics of traveling waves are discussed; equivalent circuits of terminal equipment and the corresponding reflections and refractions from such junctions were given for a large number of cases. Methods of computing a multiplicity of successive reflections by means of graphical lattices also were described. This latter is quite similar to the author's dissertation as presented at the 1930 Pacific Coast Convention at Portland, Ore.

Attenuation and Reflection

In discussing the "Attenuation and Successive Reflections of Traveling Waves," James C. Dowell, General Electric Company, Pittsfield, described a method which he had followed in segregating the individual waves from the oscillographic record of the voltage at a transition point due to the superposition of several successive reflections. In the author's opinion it is necessary to effect this separation to permit the determination of wave attenuation on a given transmission line. He stated that in the past it has not been unusual to attribute the reduction in crest value of each successive reflection to attenuation, whereas the major cause of such reduction was reflection at the terminal equipment. The author presented analyses and calculations of the information revealed in certain oscillograms of successive reflection, and stated that his calculations demonstrated that by treating the line as distortionless the behavior of artificial lightning surges on a transmission line could be computed with a reasonable degree of engineering accuracy.

To supplement laboratory information on the subject, "Impulse Tests on Substations" of the Public Service Electric & Gas Company, Newark, N. J., were reported upon by R. M. Southgate and A. S. Brookes of that company, and E. R. Whitehead and W. G. Roman, of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., These practical tests on an operating system included the surging of a 220-kv. switching station over eight miles of overhead lines. A study was made of the effects of various amounts of connected bus and station equipment, and the effect of different arrester locations.

FIELD DATA ON LIGHTNING

Further practical data were sought in a "Lightning Investigation on a Wood-Pole Transmission Line," reported upon by R. R. Pittman, Arkansas Power & Light Company, Pine Bluff, Ark., and J. J. Torok, Westinghouse Electric & Manufacturing Company, East Pittsburgh. As a result of field tests covering a total of 38 surges occurring on a highly-insulated wood-pole transmission line, the authors concluded that harmful effects are caused only by direct strokes. Of the 38 surges recorded, one reached a crest of 5 million volts and one a crest of 4½ million volts; analysis showed that these high surges were the results of lightning striking the line and causing faults between conductors but not to ground. Records obtained indicated that surge currents varied relatively from insignificant values to 100,000 amperes. The authors conclude that insulation alone does not offer a solution to the lightning problem.

Presenting his fifth annual paper on the subject of "Lightning Experiences on the 132-Kv. Transmission Lines of the American Gas and Electric Company," Philip Sporn, chief engineer of that company, discussed and analyzed the records of his system for 1929. Upon the basis of his own analyses the author has arrived at the conclusion that:

(1) Two-circuit lines are more reliable than single-circuit lines.

(2) Two ground wires are better than one.

(3) Grading shields do not reduce line outages, but decrease line damage.

(4) Direct and induced strokes must be considered.

(5) Flashovers do not concentrate on towers of high-footing resistance.

(6) Tower footing resistance must be low if an overhead ground wire is to give effective protection.

◆

Machinery Developments Emerge From Laboratory

Five papers were presented at the machinery session of the winter convention, each recording a definite advance in the knowledge of electrical machinery performance. When asked for his impressions of the session, P. L. Alger, assistant to the vice-president in charge of design engineering, General Electric Company, Schenectady; chairman of the A. I. E. E. electrical machinery committee, and chairman of the session, said:

MERCURY ARC RECTIFIERS

"Dr. A. W. Hull of the General Electric Research Laboratory described striking improvements in mercury arc rectifiers obtained as a result of extended research work, particularly on the control of current flow from the anodes. By the use of anode heaters to provide a definite mercury vapor pressure, the use of grids to increase the arc-back potential, and by other means the current-carrying capacities of rectifiers have been greatly increased, and the frequency of arc-backs has been materially reduced. New 3,000-volt rectifiers employing these new features now are in successful operation supplying all the power for the D. L. & W. electrification. In commenting on the paper, H. D. Brown, co-author with Dr. Hull, mentioned that the research work described had enabled the current capacities of rectifiers to be more than doubled in a brief time, and enabled very high momentary overload current ratings to be given. Mr. Brown also mentioned

Substation is Built in 70 Working Days

COMPLETION within 70 working days and with an average of 75 men on the job of the substation shown in the accompanying illustrations is the record established by the United Engineers & Constructors, Inc. The station was built at North Arlington, N. J., for the Public Service Electric & Gas Company (Newark, N. J.) and it is stated that notwithstanding the speed with which the job was completed the unit costs of carrying on the work were no higher than for other structures of similar design. The building is 70x30 ft., with the outdoor structure designed to accommodate four 26.4-kv. incoming lines, twelve 4.15-kv. automatically-regulated feeders, ten street-light circuits, and two 6,000-kv-a. transformer banks. At present two 26.4-kv. lines, six 4.15-kv. lines and two street-light circuits are in service.

that there is now under construction a 10,000 ampere, 625 volt rectifier.

"Gabriel Kron of the United Research Corporation, (Long Island City, N. Y.) presented a paper on the slot effects in induction motors, giving ten definite rules to predetermine vibration, "crawling," and noise. While this subject is a familiar one, and most designers have developed fairly satisfactory rules for their own use, Mr. Kron's paper presents for the first time a compact rational explanation of all these effects.

Stroboscopic Movies

"H. E. Edgerton, of the Massachusetts Institute of Technology electrical engineering staff presented a paper on the synchronizing performance of salient pole synchronous machines. His discussion was illustrated with a stroboscopic moving picture which showed the motion of the rotor as clearly as if the observer actually were carried around with the revolving flux, thus enabling the oscillations as the rotor pulls into step to be seen plainly. The solution of the salient-pole-machine synchronizing equation never has been obtained mathematically, because of its complex form, but Mr. Edgerton put the M. I. T. integraph to work on the task and with it obtained an exact solution in a form very convenient for use by designers. Discussion of the paper indicated that the results will be of immediate practical use in enabling the load synchronizing ability of synchronous motors to be accurately predetermined.

Heat Flow in Turbines

"C. R. Soderberg, Westinghouse Electric and Manufacturing Company, described a complete theory of steady-state heat flow in large turbine generators, which he has developed. The theory is based on laying out the heat-flow paths in the form of definite thermal circuits, and converting these into equivalent electrical circuits, the solution of which are in familiar form. The proportions of the total heat dissipated from the various machine surfaces were discussed, and a future paper giving experimental results was promised.

"The last paper of the session was one dealing with the effects of transient voltages on power transformers, by K. K. Palueff of the General Electric Company. This paper is the third in a series written by the author, presenting the theory and practical results of shielding as a means of reducing the voltage concentration in transformer windings under lightning and switching surges. The first two papers dealt with two-circuit transformers solidly grounded, and grounded through an impedor, respectively, while this latest paper deals with the auto transformer. The theoretical and experimental results presented show that it is possible now, by proper shielding, to control the surge voltage distribution throughout the windings of all of these types of transformer, thus greatly reducing abnormal voltage stresses and permitting simpler insulation design."

◆

Protective Devices Improve Electric Service

Developments in circuit-interrupting devices and theory easily occupied the center of the stage in the winter convention session on protective devices; not, however, to the exclusion of presentations concerning transient stability limits of power systems and current advances in lightning arrester theory and application, which also claimed general interest.

Lightning Protection

J. J. Torok, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., described "An Experimental Lightning Protector for Insulators" the operation of which was said to be similar to that of the expulsion fuse, causing the extinction of the arc at the end of the first half-cycle when the current goes through zero value. The supporting principle is that excessive potentials will set up an arc in the confining chamber, which arc is subsequently extinguished by a deionizing effect in a remarkably brief period of time, thus clearing the system of what otherwise might be a troublesome flashover.

In "Field Tests on Thyrite Lightning Arresters Using Artificial Lightning of 1,500,000 Volts" described by K. B. McEachron and E. J. Wade, General Electric Company, Pittsfield, Mass., the authors had studied that type of arrester in experimental operation on a 45-mi. transmission line. As a result of experimental findings it is proposed that line insulation shall be limited for a distance of a half-mile back from the station at which lightning arresters are installed. Oscillograms were interpreted to show that for the traveling wave used, no protection is offered by an arrester at a distance of 2,180 ft.

System Stability

In suggesting the "Series Resistance Method of Increasing Transient Stability Limits," R. C. Bergvall, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., characterized it as an "ace in the hole" of some importance in effecting station system stability, particularly in connection with hydroelectric generators of relatively low inertia as compared with the system load inertia. He presented evidence to support his contention that synchronism could be maintained readily on a hydro system of normal proportions for any type of fault if, through a combination of high-speed circuit breaker and high-speed relay operation, a series resistor of suitable proportions could be inserted in the generator neutral lead for a brief period of time.

Circuit Breaker Trends

In discussing "The Trend in Development of Modern Circuit Interrupters," J. B. MacNeill, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., reviewed briefly the major mechanical and electrical characteristics of all important contemporary devices including some foreign types. Mr. MacNeill stated that through the use of the modern high-power testing facilities now available to engineers, many of the now novel ideas for such interrupting devices may possibly be developed commercially. It is his conclusion that the several forms of circuit interrupters not using oil and which now are assuming commercial importance, should be limited in application to insulations of 25 kv. or less, and largely for indoor service only. For higher voltages he sees little competition with the oil circuit breaker in its present greatly improved forms.

"The Oil-Blast Circuit Breaker" (see page 134, Electrical Engineering, February 1931) was described at some length by D. C. Prince and W. F. Skeats, General Electric Company, Schenectady. Extensive field and laboratory tests on this breaker itself and in comparison with other types, were described at length in a paper by Philip Sporn and H. P. St. Clair, of the American Gas & Electric Company, New York, and in a paper by R. M. Spurck and H. E. Strang, General Electric Company, Philadelphia. These latter two papers presented field and laboratory test results upon the basis of which the General Electric authors stated in part that:

"A high-voltage, high-capacity breaker now has been demonstrated to have the ability to interrupt forty short circuits up to 115 per cent of its rating in a short period of time without inspection or attention and still be in condition to operate. This would indicate that in some respects the general impression of an oil circuit breaker as an unreliable device and one requiring undue maintenance may be subject to revision. Such a development appears to meet the requirements set up only a few years ago by some operating engineers for a breaker that would operate 50 times under short circuit without requiring attention."

In commenting upon the session its chairman, Raymond Bailey, assistant electrical engineer of the Philadelphia Electric Company, chairman of the Institute's protective devices committee said, in part:

> "Discussion of the oil circuit breaker papers indicated a disagreement between the research engineers of American manufacturers, on the underlying theory of circuit interruption in oil. This frank discussion of opposing views should prove particularly valuable in arriving at the final solution of the oil circuit breaker problem."

◆

Welding Session Studies Arc Characteristics

Of importance and particular significance in the field of electric welding is the trend of research and investigation toward a better understanding of the basic fundamentals underlying the electric arc itself. While the cut-and-try method based upon field experience and laboratory tests has been responsible for some noteworthy improvements in both welding equipment and procedure it stands to reason that a more intelligent and economical solution to many of the problems of that arc may be expected when the basic fundamentals of the electric arc itself are better understood. In recognition of the prominent place occupied by electric welding in the field of engineering activities is evidenced by the fact that one entire session of the winter convention program was devoted to that subject under the chairmanship of P. P. Alexander of the General Electric Laboratory, and chairman of the A. I. E. E. welding committee.

The principal contribution of fundamental research was in the discussion of "Some Experiments With Arcs Between Metal Electrodes" presented by Prof. G. M. Shrum, University of British Columbia, Vancouver, B. C., and H. G. Wiest, Jr., General Electric Company, West Lynn, Mass. and presented by Dr. Saul Duschmann, General Electric Company, Schenectady. The paper described experiments on arcs occurring between metal electrodes in argon and other gases, in which the current was controlled by means of a kenotron. Volt-ampere characteristics of the discharge for the entire transition stage from glow to arc, or the reverse, were obtained by varying the temperature of the cathode in the kenotron. According to observation the spectrum of the discharge in the arc phase is characteristic of the cathode material, at least for the smaller current values. Results obtained led the authors to state that they did not support the assumption that a temperature effect at the cathode and the resulting thermionic emission causes the glow discharge to develop into an arc. Rather, the indication is that the resulting arc is a matter of current density of the cathode.

Arc-Welding Equipment

Arc welding generators and related equipment in one form or another were discussed at some length in three papers:

1. An Improved Arc-Welding Generator, by J. H. Blankenbuehler, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
2. The Neutralized Welder—A Means of Controlling Transients, by Frederick Creedy, Lehigh University, Bethlehem, Pa.
3. A System for D-C. Arc Welding, by S. R. Bergman, General Electric Company, West Lynn, Mass.

Mr. Blankenbuehler attributed most of the trouble in starting and maintaining arcs to the operating characteristics of the welding generator involved, and presented an analysis of these troubles explaining them in terms of generator design. He described equipment including a specially designed transformer built into the circuit of a welding generator in such a manner that surges due to arc variations are practically obviated.

These three papers presented various experimental data—mathematical and of other analyses—and the results of a certain amount of practical experience. Suggestions covering the use of transformers, reactors and special machine design in varying combinations, all intended to take the peaks out of the short-circuit characteristic curves of welding generators were made by the authors. The resulting general discussions and barrage of claims and counter-claims somewhat clouded the issue so far as it concerned the accurate determination of just which one of the several ideas was conceived first or worked best. However, the consensus of opinion seemed to be that the general trend of the suggested development, and certainly the objective were correct.

Welding Methods

A method for the "Resistance Welding of Motor Frames," discussed by Malcolm Thomson, General Electric Company, Lynn, Mass., involves the use of a flash-welding process which appears to be particularly successful in this application.

The author of this paper described the process of making motor frames from flat plates rolled into cylindrical form and butt-welded by the flash process; with feet welded on by ordinary arc welding. He added that these two welding methods made possible the production of motor frames from 25 to 50 per cent cheaper than with corresponding steel castings besides adding the definite advantages of greater uniformity in dimensions and structures.

Equipment and procedure for "Electric Resistance Brazing," were described by Samuel Martin, Jr., General Electric Company, Schenectady. Equipment developed includes a special portable transformer unit complete with service extension cord, leads of convenient length, and a specially-designed brazing clamp or tongs. Soft carbon blocks are used in the tongs as the heating elements, and the metallic parts to be brazed are clamped between them, receiving all of their heat according to the author, by conduction. With this equipment and the use of silver solder, joints of much greater mechanical strength, durability, and higher electrical conductivity than the more usual soft solder joints, were said to result with an actual saving in cost per joint.

◆

Research Forms Basis For Further Development

Seven subjects, principally of a fundamental nature and revealing some noteworthy results of continued persistent efforts, were presented and discussed in a winter convention session devoted to research. L. W. Chubb, assistant to the vice-president of the R. C. A.-Victor Corporation, and chairman of the Institute's research committee, presided.

Oil Characteristics Sought

"Some Electrical Characteristics of Cable Oils" were outlined by Hubert H. Race, General Electric Company, Schenectady, who divided his presentation into three parts. His first section dealt with routine measurements of d-c. resistivity and described a quartz-insulated testing cell and portable testing set for use with it, with which it is claimed that absolute resistivity between 1×10^9 and 1×10^{13} ohms per cm.^{3} can be measured at any temperature up to 150 deg. cent. In his second section he gave data concerning the variation of the apparent d-c. conductivity of a heavy cable oil with potential gradient and with temperature showing that the conductivity is constant only for very low gradients. His third section was a summary of variations of dielectric coefficients and dielectric loss, occurring with temperature and frequency as observed for a viscous cable oil. His analysis shows that the total dielectric loss is the sum of two components, one due to conduction and the other qualitatively explained by Debye's theory of polar molecules.

In a companion paper, J. B. Whitehead, of The Johns-Hopkins University, Baltimore, presented some of the results of his further investigation into "The Conductivity of Insulating Oils." Dr. Whitehead concluded that:

(1) Certain high-grade insulating oils have electrical characteristics similar in type and comparable in magnitude to those of the carefully refined, poorly-conducted liquids used in physical research.

(2) In the purest state they show a definite though brief dielectric absorption.

(3) The initial dielectric absorption increases with decrease of temperature and thus is associated with the viscosity.

(4) The dielectric loss at less than 60 cycles alternating stress is determined definitely by the continuous-current characteristics within the interval from zero to 0.1 sec.

(5) The initial absorption conductivity and subsequent decay are not completely accounted for by the residual impurities as frequently stated.

In collaboration with Dr. Whitehead, Prof. W. B. Kouwenhoven, The Johns-Hopkins University, presented a paper on on "Fundamental Properties of Impregnated Paper." The authors jointly emphasized the importance of the initial conductivity of impregnated oils as distinguished from the final conductivity and stated that higher conductivity is reflected in increased losses arising from both reversible and irreversible dielectric absorption.

Vacuum Tubes Control Traffic

Traffic-control equipment operated automatically by light beams, one of the many and ever-increasing commercial applications of the versatile vacuum tube was described by R. C. Hitchcock, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The equipment is described fully elsewhere in this issue.

Commutation in Hydrogen

Two papers having to do with research looking toward the improvement of rotating machinery, were presented by R. M. Baker, and G. M. Little, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. As the result of experimental data collected by Mr. Baker concerning "Commutation and Current Collection in Hydrogen," he has come to the conclusion that:

(1) A commutator machine designed and adjusted for good commutation in air will operate satisfactorily and give good brush life in hydrogen.

(2) If a commutator machine must spark in hydrogen the brush life may be increased materially by maintaining less than 10 per cent humidity.

(3) Contact resistance between carbon brushes and commutator may be lowered materially by the introduction of hydrogen.

(4) Carbon or graphite brushes cannot be operated satisfactorily on plain tool-steel slip-rings running in hydrogen and that

(5) contact drop between a carbon or graphite brush and a brass slip-ring may be as much as ten times higher with the ring running in air as it is with the ring running in hydrogen.

Mr. Little has been investigating "The Application of the Helical Groove to Slip-Rings and Commutators," and has come to the conclusion that the helical groove:

(1) provides a means for forcing a more uniform distribution of current over the brush face; (2) permits the escape of air trapped under a brush; (3) prevents local spot heating under overload conditions; (4) raises the content drop of the brush, improving commutation and (5) in some cases increases brush life.

A rather comprehensive paper by C. G. Suits, General Electric Company, Schenectady, covering his "Studies in Non-Linear Circuits" and a discussion of the "Magnetic Circuit Units as Adopted by the I. E. C." prepared by Dr. Arthur E. Kennelly, Harvard University, brought the research program to a close.

◆

Railroad Electrification Problems Are Discussed

Of the five papers presented at the transportation session of the winter convention, two may be said to be of general interest in the field of transportation, and three of somewhat specific interest in that field. In commenting upon the session, Sidney Withington, electrical engineer of the New York, New Haven & Hartford Railroad, chairman of the Institute's committee on transportation, and chairman of the session said, in part:

> Mr. Moreland's paper was especially timely in that it followed closely the inauguration of one of the notable projects of the year in railroad electrification. The comprehensive description, together with the inspection trip, presented to the Institute members a somewhat unusual opportunity to learn the details of the Lackawanna electrification. Mr. Drake's paper on the Sperry fissure detector car also was timely and may well be considered a tribute to the late Elmer A. Sperry.

The five papers presented were:

1. Lackawanna Suburban Electrification, by E. L. Moreland, Jackson & Moreland, Boston.
2. Motive Power for Suburban Electrification, by Charles Kerr, Jr., Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.
3. Transverse Fissure Detector Car, by H. C. Drake, Sperry Products, Inc., Brooklyn, N. Y.
4. Inclined Catenary Calculations, by B. M. Pickens, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
5. Design of Catenary System for Cleveland Union Terminal, by N. F. Clement and E. E. Richards, Cleveland Union Terminals Company.

Mr. Moreland's paper is rather fully abstracted elsewhere in this issue.

Mr. Kerr dwelt upon the problems peculiar to suburban electric railway operation where the number of cars required during rush hours varies from two to six times that required for off-peak service. He pointed out that trailer cars may be used to advantage under these circumstances without reducing the schedule speed more than three or four per cent.

In discussing this paper, H. F. Brown of the New York, New Haven & Hartford Railroad stated that for twenty years his road had used a system similar to that which Mr. Kerr outlined, and that it worked out very well.

Faulty Rails Revealed

In introducing Mr. Drake, Mr. Withington paid tribute to the late Emler A. Sperry who was directly responsible for the development of the rail-fissure detector described in Mr. Drake's paper, and one of the last of the many contributions which Mr. Sperry has made to civilization. This presentation was illustrated by a moving picture which showed the effectiveness of the device in locating all kinds of transverse rail faults and fissures before the point of actual rail breakage. As many as 24 fissures have been found in a single rail section.

In Mr. Pickens' absence Mr. Kerr read an abstract of his paper. This paper demonstrated a unique method for calculating the space factors involved in the design and layout of inclined overhead catenary construction as required in electric railway work. His method provides for a smooth, continuous curve of contact wire from span to span, lying in a horizontal plane.

The Cleveland Union Terminal is a station which is used jointly by the several railroads entering Cleveland, and is located in a central part of the city; the electrification, which is of the 3,000-volt d-c. type, extends from the terminal some distance out in both directions, covering a total of 59 track miles. The last paper of this session explained the design details of the overhead power supply used on this electrification. The scheme consists of tangent-chord compound catenary system. Parabola formulas were used for the calculations and where feasible were made up in the form of charts.

In discussing all of the papers of this session, D. C. Jackson brought out the point that the problem involved in electric railway construction and operation was primarily one of transportation, and that the electrical engineering work involved was chiefly a means to the furthering of that end. According to Mr. Jackson the most important question to be answered is an economic one; "will the improvements possible through electrification justify themselves from a cost standpoint?"

◆

Winter Convention Attracts 1,589 Registrants

With devotion of its special attention to inductive coordination, and industrial applications of electricity and electrical devices, the winter convention, held Jan. 26-30, inclusive in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., attracted 1,589 persons, officially registered, but heavy attendance at the sessions indicated the presence of many others. As revealed by the following tabulation nearly every geographic district was represented:

District	Registrants
New York City and Foreign (3)	730
Middle Eastern (2)	515
North Eastern (1)	231
Great Lakes (5)	47
Canada (10)	42
Southern (4)	11
South West (7)	10
North Central (6)	3
Total	1,589

◆

New York Sights are Shown to Convention Delegates

In addition to its wealth of technical papers covering a wide variety of timely and important subjects, the winter convention program offered a multiplicity of entertainment features in keeping with the quality of its technical program. Inspection trips included the recently electrified divisions of the Delaware & Lackawanna Railroad and its power supply facilities; the new Hudson River Bridge, the longest single-span structure in existence; and the Empire State Building, the world's highest. Also available to all conventioners, practically at their own convenience, were such features as the Westinghouse Lighting Institute; the Chrysler Building (exceeded in height only by the Empire State Building) with its vertical distribution network; modern photo lithograph and newspaper plants; the Electrical Testing Laboratories; and various immense steam-electric generating plants, not to mention the museums and exhibitions peculiar to New York.

Particular attention was given to the women's entertainment program which included charmingly conducted luncheons and bridge teas, to say nothing of inspection trips specially chosen for their unique attractiveness, including a visit to the White Star Line Steamship "Majestic" and a practical demonstration of television at the Bell Telephone Laboratories.

For the men, if attendance be any index, the informal buffet dinner and supper was a huge success, and there truly was "standing room only" at the "The Frolics of 1931," the nine-part headliner stage show put on by the entertainment committee. Concluding the social affairs in connection with the convention was the annual dinner dance held in the Grand Ballroom of the Hotel Astor, Thursday evening, January 29, and presided over by that genial personage, President Lee.

◆

A. I. E. E. Directors Meet During Convention

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, Wednesday, January 28, 1931, during the annual winter convention of the Institute. Those present were:

President—W. S. Lee, Charlotte, N. C.

Past-presidents—R. F. Schuchardt, Chicago, Ill; Harold B. Smith, Worcester, Mass.

Vice-presidents—W. S. Rodman, Charlottesville, Va.; C. E. Sisson, Toronto, Ont.; G. C. Shaad, Lawrence, Kans.; I. E. Moultrop, Boston Mass.; H. P. Charlesworth, New York, N. Y.; T. N. Lacy, Detroit, Mich.

Directors—F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton and R. H. Tapscott, New York, N. Y.

National treasurer—W. I. Slichter.

National secretary—F. L. Hutchinson, New York, N. Y.

Present by invitation—H. A. Kidder, New York, chairman of the committee on the engineering profession.

Actions Ratified

Minutes of the directors' meeting of December 4, 1930, were approved.

Reports of meetings of the board of examiners held December 23 and January 20 were presented, and the actions taken at those meetings were approved. Upon the recommendation of the board of examiners, the following actions were taken upon pending applications:

391 Students were enrolled.

486 applicants were elected to the grade of Associate.

27 applicants were elected to the grade of Member.

25 applicants were transferred to the grade of Member.

4 applicants were transferred to the grade of Fellow.

The board ratified the action of the finance committee in approving for payment, monthly bills amounting to $33,253.52 for the month of December and $30,159.22 for the month of January.

The annual report of the president of the U. S. national committee of the International Commission on Illumination was received and ordered filed, and payment of the Institute's annual contribution of $300 to the U. S. committee was authorized.

In accordance with Sec. 22 of the constitution, N. T. Wilcox was exempted from future payment of dues, thereby being added to the list of "Members for Life."

The national secretary reported that the members in arrears for dues for the fiscal year which ended April 30, 1930, were dropped from the membership list on December 31, 1930, with the exception of those who had requested an extension of time for the payment of these dues. The members dropped totaled 739 including 2 Fellows, 40 Members, and 697 Associates.

1932 Institute Meetings

The committee on coordination of Institute activities reported a recommended schedule of national and district meetings for the calendar year 1932, based upon applications for meetings received from district executive committees in response to a request of the coordination committee that such applications be filed by January 1,1931. The schedule included all requests for meetings that were received. The Board voted to approve the recommended schedule of meetings for 1932, as follows:

January 25-29, Winter convention, New York, N. Y.

March 14-16, District meeting (No. 5), Milwaukee, Wis.

May (early), District meeting (No. 1), Providence, R. I.

June 20-24, Summer convention, (location to be decided later).

Aug. 29-Sept. 2, Pacific coast convention, Vancouver, B. C.

October, District meeting (No. 2), Baltimore, Md.

November, District meeting (No. 4), Memphis, Tenn.

Upon request of the executive committee of the North Eastern District, the dates of the Rochester district meeting were changed from May 6-9, 1931, to April 29-May 2, 1931.

NEW SECTION

Upon the recommendation of the sections committee, the territory of the Louisville section was extended to include the remainder of Woodford County and all of Fayette and Jessamine Counties, and a new section was authorized; namely, a Florida section, to include as its territory the entire state.

As recommended by the committee on student branches, authorization was given for the organization of student branches at the University of Illinois, Urbana, Ill., and Rice Institute, Houston, Tex.

STANDARDS SPECIFICATIONS

Upon recommendation of the standards committee, approval was given to the following specifications developed by the sectional committee on insulated wires and cables:

Specification No. 12—Weatherproof (weather-resisting) Wires and Cables.

Specification No. 12A—Heat-Resisting Wires and Cables.

Specification No. 4—Code Rubber Insulation for Wire and Cable for General Purposes.

These specifications were approved for publication in the regular A. I. E. E. series of pamphlets dealing with standards and related material.

MISCELLANEOUS ACTIONS

Amendments to the By-laws were adopted, changing the following references therein to conform to changes in names which have already gone into effect: "Journal of the A. I. E. E." changed to read "Electrical Engineering," "Engineering Foundation, Inc." changed to read "United Engineering Trustees, Inc.," "Engineering Societies Research Board" changed to "The Engineering Foundation."

Appointment of two representatives of the Institute on the Council of the American Association for the Advancement of Science for the year 1931 was referred to the president.

The designation of delegates to attend the annual meeting of the American Academy of Political and Social Science, Philadelphia, April 17-18, 1931, was referred to the president.

A communication from the Museum of Science and Industry, Chicago, enclosing an outline of proposed exhibits in the museum on the subject of electric power and asking for comments, was referred to the Chicago Section of the Institute.

It was voted to hold the March meeting of the board of directors in Pittsburgh, during the district Meeting of the Institute, March 11 to 13.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

◆ ◆ ◆

Some Winter Convention Discussions are Summarized

A SUMMARY of some of the many discussions presented at the first four sessions of the winter convention is given herewith. Only discussion submitted in writing in accordance with A. I. E. E. rules governing it is summarized; complete discussion together with all papers so approved will be published in the TRANSACTIONS. A list of papers presented was published in the January issue of ELECTRICAL ENGINEERING. Later discussions will be summarized in subsequent issues.

Symposium on Telegraphy

E. R. Shute discussed "Newfoundland-Azores Duplex Cable." Referring to Fig. 1 of the paper he pointed out that this cable forms the diagonal of a quadrilateral, and in the event of a cable failure or stoppage of any of the cables the resulting triangular circuit layouts tend to maintain continuity of service.

INTERFERENCE

A. W. Breyfogel discussed "Submarine Cable Telegraphy—Influence of Interference." He stated that the paper gives the theoretical as well as the practical means for determining the magnitude of the effect that transient forms of interference will have upon the receiving instrument; but it does not give the practical means available for minimizing the effect of such disturbances. Where interference is present, it is always of advantage to tune the receiving equipment to the lowest practical frequency consistent with reception of satisfactory shaped signals. This generally permits reception at a higher speed than might otherwise be obtained.

TRANSMISSION TESTING MACHINE

H. H. Haglund in his discussion on "Telegraph Transmission Testing Machine" stated that the machine has many other uses besides the testing of telegraph transmission. It is used for comparing the speed of oscillating systems of comparatively low frequency such as electrically-driven tuning forks. Mr. Haglund told of five methods which in the past have been so commonly employed for this purpose.

P. B. Shanck in his discussion on "The Telegraph Transmission Testing Machine" believed that the machine is particularly well suited to the investigation of distortion which, with a regularly-recurring signal, oscillates through a definite cycle so as to form a regular pattern as is the case with a-c. interference.

PRINTING CONCENTRATOR

C. M. Brentlinger, in discussing "A Printing Telegraph Concentrator" explained that the concentrator was developed to give very fast service without incurring prohibitive operating expense. He also pointed out in his discussion the advantages of splitting circuits into several 100- or 200-wire units instead of putting them all in one large unit. These are as follows: space limitations imposed by the need of other equipment before each operator, a saving in cable expense, a possible saving effected in the provision of equipment to care for future growth, and greater flexibility of operation.

PRIVATE-WIRE SERVICE

H. H. Nance discussed "Modern Practises in Private-Wire Telegraph Service" with special reference to the operation of voice-frequency carrier telegraph systems on channels of carrier-telephone systems. He cited the value of the flexibility of this method that resulted when line trouble encountered during a recent severe storm in the mid-west caused the re-routing of service.

Symposium on Coordination of Power and Telephone Plant

J. J. Smith in discussion of "Trends in Telephone and Power Practise As Affecting Coordination" did not believe that the references in the paper to the use of transformers with graded insulation and Y-Y transformers were representative of the more usual type of practise on power systems. A large proportion of 220-kv. transformers are so constructed but for 66-kv. systems and above, a large proportion of the transformers have sufficient insulation on the neutral end of the winding to permit the insertion of considerable impedance between line and ground. He also pointed out that the use of delta-Y instead of the Y-Y connection is by far the more common practise.

NOISE-FREQUENCY INDUCTION

In discussion of "Status of Joint Development and Research on Noise-Frequency Induction," J. J. Smith predicts the introduction of the use of vacuum tube devices on a fairly large scale within the next decade. He also calls attention to fact that some of the work of the Joint General Committee is of interest in other fields, such as electrical machinery, elimination of street noise, etc.

M. D. Hooven in discussion of the papers in the symposium called attention to the educational value of the material presented, and in particular, with reference to the problem of low-frequency induction. He also cited the importance of cooperative advance planning which was expressed in the last three papers of the symposium.

W. W. Lewis read a discussion prepared by L. T. Robinson on the papers in the symposium and which brought out the fact that a similar problem exists in the relation of the use of radio to other electrical industries. The three factors defined in the papers—namely "Influence Factor," "Susceptiveness Factor" and "Coupling Factor"—also exist and have the same importance in the radio communication field.

LOW-FREQUENCY INDUCTION

H. S. Phelps discussed "Status of Joint Development and Research on Low-Frequency Induction." He remarked "that the paper should be most helpful to one called upon to outline the essential feature of low-frequency induction." In further discussion he commented upon the benefits of the shielding effects that may be derived from the proper use of ground wires.

L. P. Ferris discussed "Status of Joint Development and Research on Low-Frequency Induction." Showing the effect of diminishing-earth conductivity on the permissible closeness of power and telephone lines with the aid of a curve prepared from field data, and by considering a hypothetical case.

H. M. Trueblood discussed "Joint Development and Research on Low-Frequency Induction." He explained that the division of the work is such that some of the project committees are engaged upon questions relating very largely to telephone systems, while others are giving their attention to questions which concern power systems almost exclusively. Each project committee is made up of members representing both industries so that the power and telephone engineers are getting pretty well acquainted with each other's problems.

D. H. Gage discussed "Status of Joint Development and Research on Low-Frequency Induction," with relation to the interference on telegraph lines as caused by power lines. He believed that there is a field for investigation in cases where unexpected interference results from an exposure of a communication line to an apparently well-balanced power circuit, with very little current in the neutral. He also cited a situation where short exposures at different places on the same line which while alone would not cause serious interference, but when they were combined in certain ways, materially affected the operation of communication circuits.

JOINT POLE USE

D. H. Gage also discussed "Status of Cooperative Work on Joint Use of Poles" and brought out the question of joint-line agreements with particular reference to the character of circuits on jointly-used poles; also the question of liability. He believed engineers should give these questions careful consideration, even though they might seem outside the scope of an engineering study.

Protective Devices Session Discussion

STABILITY

S. B. Crary in discussion of "Series Resistance Method of Increasing the Transient Stability Limit" pointed out that the practical gain to be realized from the use of the series-braking resistor decreases with faster switching time.

J. W. Anderson in his discussion of this paper gave some actual figures of acceleration serving to emphasize the marked tendency of hydroelectric generators to overspeed upon loss of load immediately after a short circuit occurs. This was pointed out by Mr. Bergvall in his paper.

G. D. Floyd, discussing "Series Resistance Method of Increasing the Transient Stability Limit," believed that from the calculations and tests covered by the paper, zero resistance at point of fault might be inferred. He pointed out that the inference is justified for three-phase faults, but in cases of single- and double-line-to-ground faults where there might be high resistance at fault location, the added resistance in the generator leads might cause a drop in the unit's speed sufficient to make it lose synchronism.

H. S. Phelps in discussion of "Series Resistance Method of Increasing Transient Stability" took exception to the idea expressed in the paper that instead of trying to solve the stability problem by building lightning-proof lines consideration might be given to building lower-cost transmission lines that would be expected to flash over. He pointed out that this conclusion must be considered in conjunction with the views expressed in the symposium on coordination of power and telephone plants.

CIRCUIT INTERRUPTING DEVICES

Philip Sporn discussed "Trend in Development of Modern Circuit Interrupters" and commented upon the advances made within the last three or four years in the oil circuit breaker field. He expressed disappointment, however, in the lack of progress in the development of an oil-less interrupting device.

C. L. Fortescue in discussion of "Trend in Development of Modern Circuit Interrupters" commented on the various principles of oil circuit breakers, emphasizing the noiselessness and smoothness with which the deion circuit interrupter and the deion-grid oil circuit breakers operated.

R. M. Spurck in discussion on this paper commented upon the attempts that have been made to eliminate oil from high-duty circuit-interrupting devices. He believed that although workable devices not requiring oil have been developed there is a question whether or not the entire elimination of oil does not introduce some handicaps which are greater than those it has tried to eliminate.

Philip Sporn in discussion of "Oil Circuit Breaker Tests—Philo 1930" pointed out that the present OCO-two minutes-OCO breaker duty cycle does not meet actual operating conditions or practise. He expressed a need of bringing Institute standards and service practise into closer conformity.

J. B. MacNeill discussed "The Oil-Blast Circuit Breaker" and he pointed out that some of the ideas advanced in the paper seemed to be at variance with well-established facts about arc behavior He believed that at some point on the arc. tip the arc would form a crater which would move about but never permit the arc to envelop the tip. In consequence the oil and gas would rush past the arc, partly into the hollow electrode and partly out the explosion pot throat, through the regular contact clearance instead of passing through the arc as claimed in principle in the paper.

In discussion on "Field Tests on Standard and Oil-Blast Explosion Chamber Oil Circuit Breakers," H. M. Wilcox cited a number of tests that have been made on oil circuit breakers equipped with deion grids. The average performance of the deion-grid circuit breakers on all of these tests ranged from 7,000 to 8,000 volts per inch, with a grand average of 7,500 volts per inch of total arc length as compared with a performance of 4,050 volts per inch on the 140-kv. tests of the oil-blast circuit breaker under average circuit conditions.

Power Transmission Session Discussion

Traveling Waves

C. L. Fortescue's discussion on "Traveling Waves on Transmission Systems" was read by J. J. Torok. He expressed interest in finding that in making computations, Mr. Bewley used the method of successive reflections; he further stated that to determine proper clearances, etc., for lightning calculations this method is simple and direct and is sufficiently accurate.

H. L. Rorden's discussion of "Traveling Waves on Transmission Systems" was read by J. G. Lusignan, Jr., who emphasized the importance of experimental verification of mathematical treatment and described tests of traveling waves made with the cathode ray oscillograph. The results obtained with line conditions as given by Fig. 10D of Mr. Bewley's paper were illustrative of the general correlation found.

O. Ackerman's discussion of "Attenuation and Successive Reflections of Traveling Waves" was read by E. Beck, and pointed out the results of this paper as pertaining to attenuation which deviated from any previous results reported. Figs. 12 and 13 of the paper indicate that in a travel of 85 microseconds, corresponding to about 16 mi. surges decrease only 10 to 20 per cent. Previously reported tests indicated that surges over a 16-mi. stretch attenuate to about one-half their original value.

L. V. Bewley read a discussion which E. W. Boehne prepared on this paper. In the light of information gathered from field observations it pointed out one additional way in which corona affects the attenuation of voltage surges.

Lightning Investigations

L. V. Bewley in discussion of "Impulse Tests on Substations," commented upon the fact that the paper gives a number of oscillograms showing the effect of bus structure, breakers, and transformers, on traveling waves; however, conclusions were not drawn as to the characteristic effect of station equipment on traveling waves.

L. V. Bewley in discussing "Lightning Investigation on a Wood-Pole Transmission Line" gave the definitions and derivations of the self- and mutual-surge impedances of the equivalent conductor which replaces any number of conductors in parallel.

C. L. Fortescue's discussion on "Lightning Investigation on a Wood-Pole Transmission Line" was read by Mr. Garnett. He pointed out that Fig. 11 in the paper cannot possibly be a cathode ray oscillograph record of what happened on the line itself as on either side of the lightning experimental station 4½ mi. distant, the line was provided with fused drain points having a flashover of from 800 to 1,000 kv. for long surges. He asserted that the record was false, and that it was due to something influencing the cathode ray oscillograph circuit directly instead of through the line.

E. C. Williams read a discussion prepared by C. E. Ambelang and F. E. Andrews on "Lightning Investigation on a Wood-Pole Transmission Line." In this they reported their experience with lines of voltage lower than those of 110-kv. investigated by the authors, but their experience substantiates that cited in the paper; their conclusions also correspond.

J. J. Torok discussed "1929 Lightning Experience on the 132-Kv. Transmission Lines of the American Gas and Electric Company." He analysized the author's data, interpreting it on a direct stroke basis. In further discussion J. J. Torok stated that the paper shows markedly the importance of adequate ground-wire protection. He predicted that if two ground wires properly located were used instead of one on the Turner-Logan Line, the number of flashovers would be reduced from thirteen to one or two.

R. N. Southgate discussed "1929 Lightning Experience on the 132-Kv. Transmission Lines of the American Gas and Electric Company." He described a case where a lightning stroke was photographed, and then located as having struck the ground about 2,000 ft. from the station. The location of this stroke was placed within 350 ft. of a 220-kv. line to which an oscillograph was connected, and within 275 ft. of the live 132-kv. line. A surge was not recorded and a trip-out on the 132-kv. line did not occur, which indicates immunity of lines of this nature from induced strokes and lends support to the direct-stroke theory.

L. V. Bewley discussed "1929 Lightning Experience on the 132-Kv. Transmission Lines of the American Gas and Electric Company." One of the points which he explained and illustrated mathematically was that a flashover on the bottom conductor might be due to a direct stroke on the ground wire rather than an induced surge.

A summary of some of the discussions of the papers presented at the later sessions of the convention will be given in a subsequent issue.

A. S. T. M. To Meet in Pittsburgh

A regional meeting and dinner of the American Society for Testing Materials will be held in Pittsburgh at the William Penn Hotel March 18, 1931. The program constitutes a symposium on welding, and the Pittsburgh section of the American Welding Society is in cooperation.

The sessions include:

1. General survey of welding processes
2. Welding processes applicable to aluminum
3. The quality of materials for fusion welding
4. Modern applications of arc welding
5. Recent developments in gas welding and cutting
6. Stethescopic examination of welded products
7. Tests of welding made by the Watertown Arsenal
8. Magnetic methods of testing butt welds
9. Fatigue and impact testing of welded products
10. Welded inspection.

◆

Rutgers University Plans European Tours

Russia with its new experiments and many aspects of engineering as well as of industrial management, will be the object of practical observation and study by a party which will tour that country during the summer of 1931 under the leadership of Parker H. Dagget, dean of the college of engineering at Rutgers. It is planned also that a party of educators and travelers studying social conditions will make the tour through Russia and Europe under the direction of Prof. N. C. Miller, head of the Rutgers University Extension Division.

The tour now is being organized with headquarters at Rutgers University, New Brunswick, N. J., the expectation is to visit in addition to Russia, cities in Germany, Austria, France, Sweden, Finland, Denmark, Switzerland, and Poland. The entire group is scheduled to sail from New York July 4, 1931.

◆

Turbine Inventor Chas. Parsons Passes Away

Sir Charles Parsons, K. C. B., inventor of the steam turbine design bearing his name, passed away February 11, 1931, while aboard ship on a West Indies cruise. He was 76 years old.

The steam turbine upon which he began experiments in 1884 represents but one of his many contributions to science and mechanics. Sir Charles evoked much comment while visiting in the United

States in 1924, when he made a plea for the founding of an international corporation to dig twelve miles into the crust of the earth. He contended that the water power supply of the world was being depleted rapidly and that it might be possible to harness the heat that lies deep beneath the surface of the globe.

During the World War Sir Charles served on numerous government committees. He was knighted in 1911. Later he served terms as president of the Institute of Physics, the British Association, and other similar organizations. Among the many scientific awards received by him was the medal of the Royal Society, of which he was a fellow. Sir Charles was chairman of the numerous industrial corporations which manufactured his turbines and other inventions.

◆

Lehigh University to Hold Welding Symposium

The subject of welding and its progress each year in process and equipment. is comprehensively handled in the welding symposium presented annually by Lehigh University. This year the symposium will be held on Friday, March 27th; and one of the important papers will be that presented by J. C. Hodge of the Babcock & Wilcox Company. Mr. Hodge has made important improvements and contributions to the art of welding, and is in position to speak authoritatively concerning this important branch of engineering activity.

In addition to the discussion, there will be many demonstrations of all of the different types and methods of welding; and this year a special feature, which will reflect the most recent progress in the art in accordance with scientific development, will demonstrate the equipment and process of testing welds by gamma rays.

The success of the symposium in advancing the art of welding has been evidenced in the past by the heavy attendance of engineers from many industrial districts.

◆

Research Assistantships Offered by U. of Illinois

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in its engineering experiment station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

Appointments are made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a research graduate assistant (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the Director of the Station each year not later than the first day of April. Preference is given those applicants who have had some practical engineering experience following the completion of the undergraduate work. Appointments are made in the spring, and they become effective the first day of the following September. Additional information may be obtained by addressing The Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

◆

Business Conditions Reflected by "Indicators"

The following table of "selected business indicators" gives a comprehensive view of the business situation at the beginning of February. It is a new and easily understood tabulation, devised by a conference of statisticians in industry which meets once a month under the auspices of the National Industrial Conference Board, Inc., New York.

The conference represents more than 8,000 industrial firms throughout the United States and its statistics are compiled each month for the preceding month.

SELECTED BUSINESS INDICATORS

	Jan. 1931 expressed as percentage of:		
	Dec. 1930	Oct. to Dec. 1930 average	Jan. 1930
Basic Production			
Auto. U. S. A. and Canada	114	122	64
Building contracts	91	81	70
Steel ingots[1]	119	103	65
Pig iron[1]	103	89	60
Bituminous coal	98	95	78
Machine tool shipments	88	89	41
Machine tool orders	100	93	37
Copper, N. and S. America	96	91	77
Cotton cloth, standard	108	105	78
Newsprint paper	102	97	87
Electric power	102	100	94
Basic Consumption			
Steel orders unfilled	105	112	92
Cooper shipments	80	87	86
Machine tool orders unfilled	88	80	32
Crude rubber	133	119	78
Silk taken by manufacturers	89	98	68
Stocks on Hand			
Crude rubber	103	109	116
Copper in U. S. A.	98	97	121
Raw silk in storage	89	98	68
Newsprint paper	104	95	149
General Trade			
Carloadings, total	106	89	86
Merchandise and miscellaneous	104	86	88
Advertising lineage, newspapers	93	86	86
National magazine cost	71	64	87
Retail Trade			
Department stores[2]	106	103	93
Mail order[2]	86	84	
5 and 10 cent stores[2]	115	115	105
Business failures, number	131	149	120
Business failures, liabilities	113	145	155
Wholesale prices, general[3]	90	97	83
Wholesale prices, raw materials	101	98	80
Wholesale prices, semi-manufactured	97	96	78
Wholesale prices, finished	98	96	86

1. Average daily basis.
2. Corrected for monthly variation.
3. Estimated.

North Eastern District Meets at Rochester Apr. 29

A four-day meeting of the North Eastern District of the A. I. E. E. will be held at Rochester, N. Y., April 29 to May 2, 1931. Headquarters will be at the Sagamore Hotel.

The city of Rochester possesses many features which should prove most interesting to visitors attending the meeting; geographically located on the southern shore of Lake Ontario, and built upon the banks of the Genesee River falling 261 ft. in three cataracts within the city limits, it has all the natural resources which go to make a city attractive. From an industrial point of view Rochester is an important manufacturing center. It is the home of such well-known plants as the Eastman Kodak Company, the General Railway Signal Company, and the Stromberg-Carlson Telephone Manufacturing Company.

Technical Sessions

Four technical sessions which have been tentatively planned by the local committee will be built around: (1) Selected Subjects, (2) Research, (3) Symposium on Noise in Electrical Machinery, and (4) General Distribution. At these sessions many interesting papers will be presented, several of them dealing with the subject of lightning in relation to distribution systems.

A list of the papers to be presented and more complete details of the meeting will appear in the April issue of Electrical Engineering.

◆

Mining Engineers Register Another Successful Annual Meeting

With a general attendance of over sixteen hundred members and guests the 140th annual meeting of the American Institute of Mining and Metallurgical Engineers meeting in the Engineering Societies Building, 29 West 39th St., closed February 19th proclaimed by all in attendance as thoroughly successful. The year's progress in mining and metallurgical fields had been definitely and interestingly presented and discussed; entertainment occupied a liberal portion of the program and two medal awards and one prize award conferred for distinguished service.

William H. Pierce, vice-president of the American Smelting & Refining Co. who has made abundant contributions to the art of mechanical casting, electrolytic refining, and copper converting, notably the Smith-Pierce basic converter, which has long stood supreme, received the James Douglas Medal for his numerous designs and improvements of devices and machinery for smelting, refining and rolling copper. This medal was established by anonymous donors to commemorate the work of Dr. James Douglas, twice president of the Institute of Mining engineers and an earnest worker for the cause. The William Lawrence Saunders medal, awarded "for distinguished achievement in mining" was conferred upon Francis William Maclennan, the second McGill University man to win it since it was established in 1927.

The Robert Woolston Hunt prize and medal, won by Doctor E. C. Bain in 1929, this year went to one closely associated with Doctor Bain in much of his work—Edmund Sharington Davenport, research engineer for the Eastern Malleable Iron Company, the Westinghouse Lamp Company, and now with the United States Steel Corporation at Kearny, N. J. His studies have dealt specifically with cast iron, tungsten, thorium, and the transformation of autinite at constant subcritical temperatures.

The election of officers for the ensuing year makes Robert E. Tally, executive vice-president in charge for the United Verde Copper Company, New York, director and president; Howard N. Eavenson, consulting engineer, Pittsburgh, and H. A. Guess, managing director of the American Smelting & Refining Company of New York, directors and vice-presidents; and Louis S. Cates of the Phelps Dodge Corporation, Karl Eilers, consulting metallurgist, S. R. Elliott, general superintendent of the Cleveland Cliffs Iron Company, Ishpeming, Michigan, H. G. Moulton, consulting engineer, New York, and William Wraith, of the Inspiration Consolidated Copper Company and the Andes Copper Mining Company of New York, directors.

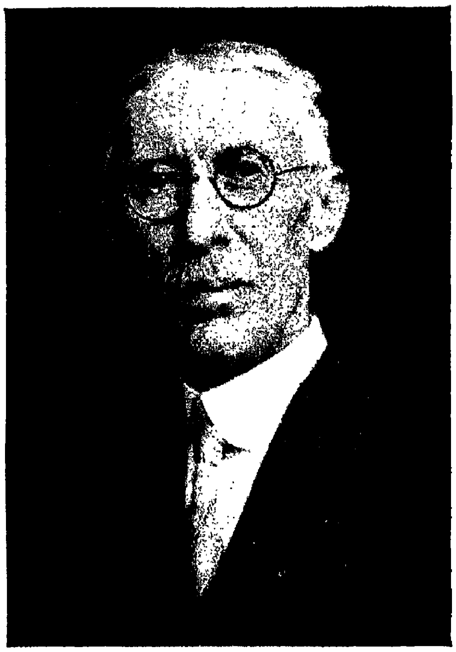
Personal

William J. Foster is Awarded Lamme Medal

Dr. William J. Foster of Schenectady, N. Y., has been awarded the Lamme Medal of the American Institute of Electrical Engineers "for his contributions to the design of rotating alternating current machinery," and will be presented at the summer convention of the Institute which is to be held in Asheville, N. C., June 22-26, 1931.

William James Foster, Sc. D., consulting engineer (retired) General Electric Company, was born in Argyle, N. Y., September 17, 1860. His college preparatory work was done partly alone with borrowed textbooks and partly at an academy and a boarding school. After graduating from Williams College with an A. B. degree in 1884, he remained a year for advanced work in mathematics. During the next five years, he taught high school subjects, and made an intensive study of physics. The degree of Master of Science was conferred upon him by Cornell University in 1891, following a year of graduate study.

In the summer of 1891, Dr. Foster began his engineering career in the Thomson-Houston Works in Lynn, Mass.; a few months later he was assigned work on synchronous converters. On October 1, 1892, he became assistant engineer, and began at that time a close association with Dr. H. G. Reist which continued for thirty-seven years.



DR. WILLIAM J. FOSTER

Beginning in 1893 and extending through several years, his association with Dr. Steinmetz also was very close. During this period, Dr. Foster assisted in general improvements, developed retardation tests, and originated tests for measuring short-circuit losses. His drafts of test methods involving heat runs, overloads, temperature rises, etc., through Dr. Steinmetz were submitted to the Committee on Standardization of the A. I. E. E. and adopted as standards.

During most of his engineering life he has had general charge of the electrical designs of a-c. rotating machines, built by the General Electric Company. For about twenty-five years, beginning in 1895, he made practically all the calculations on the most important generators that were built by this company.

He joined the Institute in 1907, and was transferred to the grade of Fellow in 1916. He served as a member of the Committee on Electrical Machinery for ten years, and was Chairman during the year 1928-29.

His other memberships include the American Association for the Advancement of Science and Phi Beta Kappa.

◆

E. C. Stone Named Vice-President Philadelphia Co.

E. C. Stone, vice-president of the Institute, was appointed on February 1st assistant to the senior vice-president of the Philadelphia Company and its subsidiaries.

Mr. Stone is a native of Charlestown, N. H.; following graduation from Harvard University in 1904, he immediately became affiliated with the Westinghouse Electric & Manufacturing Company at East Pittsburgh as an engineering apprentice, later entering the engineering department engaged in the design of transformers. In 1911 he joined the Allegheny County Light Company in Pittsburgh which two years later became the Duquesne Light Company. In 1913 he organized the system operating department for the lighting of the city of Pittsburgh, acting until 1919 as system operator; then he was promoted to the office of technical assistant to the general manager. In 1922 he became planning engineer, a position in which he organized and developed the planning division. In 1927 he again received promotion to become system development manager.

E. C. STONE

Mr. Stone has just relinquished his duties as chairman of the engineering national section of the National Electric Light Association. He is a member of the advisory board of the International Electrotechnical Commission and a member of the Association of Iron and Steel Electrical Engineers and the Engineers Society of Western Pennsylvania.

◆

E. A. Hester, formerly planning engineer of the Duquesne Light Company has been placed in charge of the newly formed operating systems planning division of the company's vice-president and general manager's office, taking over the previous duties of E. C. Stone, former system development manager.

◆

B. M. Jones, formerly general engineer of the Duquesne Co. has been promoted to planning engineer, the position vacated by Mr. Hester, and will be directly responsible for the planning and orderly development of company system and the preparation of the annual capital improvement budget.

◆

Richard H. Ranger has entered consulting engineering practise, to specialize in radio, acoustics, and general electronic technique. With him are four of his former associates in the Radio Corporation of America. The R. C. A. retains him in matters of radio picture transmission.

Previous to joining the R. C. A. ten years ago, Major Ranger was Commanding Officer of the Signal Corps Laboratories at Fort Monmouth. His first work in the R. C. A. was building the long wave, transatlantic receiving stations of that company—notably that at Riverhead, Long Island. Subsequently, he built the first R. C. A. broadcasting station at Aldene, N. J., and started the broadcasting stations, WJZ on top of the Aeolian Building, and of WRC in Washington. He was identified also with the first ship-to-shore telephony on the S. S. *America.*

◆

Frank W. Smith, vice-president, general manager, and a director of the United Electric Light & Power Company and chairman of the board of the New York and Queens Light and Power Company, two of the five companies composing the New York Edison System, has been made a vice-president of the New York Edison Company. Mr. Smith is very much of a pioneer in the arc light field; when a lad of thirteen he engaged with the United States Illuminating Company, and by the time he had reached the age of sixteen, had become general clerk. In 1889 when the United Company was formed, he was paymaster, and at twenty-four, assistant auditor. Since 1912 he has been a vice-president of the Brush Electric Illuminating Company, having priorly served both this company and the United Company as secretary.

Clarence L. Law, general commercial manager of the New York Edison Company and assistant to vice-president of the Yonkers Electric Light & Power Company was elected president of the Electrical Association of New York at its recent annual meeting. As general secretary, director, treasurer, and president of the Illuminating Engineering Society, Mr. Law is a prominent figure in the electrical industry; he also has served the National Electric Light Association as chairman of numerous committees, and has been active in the Empire State Gas and Electric Association, American Institute of Electrical Engineers, Association of Edison Illuminating Companies, and American Association for the Advancement of Science.

◆

Roy Wilkins, according to ratification by the stockholders of the Pacific Electric Manufacturing Company, San Francisco, has been appointed its vice-president in charge of engineering. Mr. Wilkins joined the organization Jan. 1, 1928 in a consulting capacity, and for fifteen years prior to that date had been associated with the Pacific Gas and Electric Company; he has conducted many hydroelectric and high-voltage experiments and is well known to the industry for his corona research and his knowledge of high-voltage oil circuit breakers. He has always taken an active part in Institute affairs and those of the Pacific Coast Electrical Association.

◆

Douglas Montgomery, who was previously electrical engineer in Pasadena, California, has been for the past year, lacking some three weeks, in Buenos Aires with the Western Electric Company, Inc. of Argentina, (local foreign subsidiary of the Electrical Research Products, Inc.), operating as service supervisor for the company's Buenos Aires district. Mr. Montgomery has been "seeing to it that from 18 to 38 motion picture installations kept their company voices in any one of the several languages—Spanish, French, English, or German."

◆

Frank B. Steele, until recently vice-president and general manager of the Utica Gas & Electric Company, Utica, N. Y., has opened offices in that city for the general practise of engineering. Mr. Steele will specialize in heating, power, electrical and pumping problems, tests and reports on private industrial power plants, design of steam, hydro, heating and pumping plants and transmission, substations and distribution systems. After eleven years in its service he resigned as an officer of the Utica utility two years ago. He is a member of the

A. I. E. E., N. E. L. A., and the American Gas Association.

◆

L. M. Cargo, Mountain States representative of the Westinghouse company, Denver, Colo., whose election to the presidency of the Electrical League of Colorado is announced, is a real veteran in the electrical business, having been continuously with the same firm for 42 years, 33 of which have been spent in the Rocky Mountain region.

◆

Byron E. White of the Utica Gas & Electric Company has been named division engineer of the central division of the Niagara Hudson Power System. Mr. White's appointment follows more than 25 years' experience in the engineering department of the Utica Gas & Electric Company.

◆

J. G. Corrin, who has been with the transformer division of the Allis-Chalmers Manufacturing Company in Los Angeles, has resigned to join American Brown Boveri Company, Inc., in New York City, as a special transformer representative. Mr. Corrin went to the Pacific Coast from New York seven years ago; he was formerly district manager for the Pittsburgh Transformer Company, later joining Allis-Chalmers when that company took over the Pittsburgh company.

◆

Robert S. Hale, long associated with the Edison Electric Illuminating Company of Boston, has resigned. Mr. Hale was a graduate of Harvard and obtained his M. E. degree at Cornell. From 1893 to 1895 he was assigned to special engineering work with the Boston Edison Company and from 1910 has been in charge of the special research department, where, as an authority on utility economic problems, he became widely known throughout the electrical industry.

◆

S. P. Larsen, for the past four years northwest manager of the Line Material Company, Portland, Ore., has been made district sales manager in the Northwest for Hubbard & Company, pole-line hardware manufacturers of Pittsburgh, Chicago, and Oakland, Calif. Mr. Larsen will transfer his headquarters from Portland to Seattle.

◆

Otto Snyder, president of New York Power & Light Corporation and in charge of eastern division activities of the Niagara Hudson Power Corporation System at the February 5th meeting of its board of directors was elected a vice-president of Niagara Hudson system.

◆

George E. Deming, works manager of the Philadelphia Storage Battery Company, has been named as its executive vice-president and Walter E. Holland, chief engineer, becomes vice-president in charge of engineering.

◆

J. R. Murphy has received appointment as manager of the General Electric Company at Spokane, succeeding Bernhard Olsen, who has been transferred as local manager of the company's Indianapolis office.

◆

Harvey H. Hoxie has been appointed San Francisco manager of the Joslyn Company of California. Mr. Hoxie has been associated with the San Francisco office of the company for some time.

◆

Mathew S. Sloan, at the organization meeting of the board of directors of the New York Edison Company, was reelected president.

Obituary

C. L. Doub, assistant engineer of the Reading Company and an Associate of the Institute (1922), died at the age of thirty-four, January 21. Mr. Doub was born at Washington, D. C., and was a graduate of Johns Hopkins University. In 1918 he became substation operator for the Hagerstown & Frederick Railway, Maryland, but continued to study in a Westinghouse graduate student course, which he completed in 1920. Prior to joining the Reading Company, he was assistant engineer of the Illinois Central Electrification Work. His affiliation with the Reading Company dated back to 1927.

◆

Harry B. Alverson, for the past thirty years a member of the Institute, and for a long period identified with the Buffalo General Electric Company as its electrical engineer, died on January 25th after an illness of several weeks. He had left the Buffalo General Electric shortly before he was taken ill and was apparently well on the road to recovery when he suffered a relapse.

A native of Portage, Wisconsin, he was graduated from the University of Wisconsin in 1893. This was followed by a course at Cornell University.

He was an active member of the Institute's Niagara Frontier Section, and his death terminates a long and useful professional career.

◆

Elwood F. McLaughlin, district manager of the central station department of the southeastern district of the General Electric Company, Atlanta, Ga., died in the local hospital of that city on January 8th, following an attack of pneumonia. He was a prominent and popular member of the Institute's Atlanta Section; one upon whom the Section's officers always could depend for wholehearted cooperation. Mr. McLaughlin was born in Philadelphia and at the time of his death was forty-seven years of age. He was graduated with the class of 1905 from Pennsylvania State College and immediately entered the steam turbine testing department of the General Electric Company at Lynn, Mass.

He was a member of the A. S. M. E., had served as chairman of its Atlanta section, and always took a leading and active part in all local enterprises of both A. I. E. E. and A. S. M. E. plans. He was a member also of the Atlanta Athletic Club, entering into its work with the same vigor and enthusiasm which typified all of his affiliations. He first joined the Institute in 1922.

◆

John Lundie, president of the Lundie Engineering Corporation, New York City, and an Associate of the Institute since 1899, died at his home on Seventy-Second Street after an illness of several weeks. He was 73 years old,—a noted consulting engineer and inventor of many railway devices bearing his name:—the Lundie tie-plate, rheostat, duplex rail anchor and the "telfer," a combined electrical hoist and traveler. Mr. Lundie was born in Arbroath, Scotland, obtained his early education there, and received his Bachelor of Science degree from Edinburgh University in 1880. This was supplemented by an honorary degree of Doctor of Science conferred by the same university in 1902. From 1873 to 1877, while still pursuing his studies, he was engaged in harbor work at Dundee. Immediately after leaving the university at Edinburgh, he came to this country, spending the next four years employed in railroad engineering in Oregon and Washington. From 1884 to 1890, municipal work in Chicago claimed his attention;

this was followed by three years of bridge construction work. In 1893 he began his practise as consulting engineer.

Doctor Lundie was member of the American Society of Civil Engineers, the American Association for the Advancement of Science, the American Institute of Consulting Engineers, the American Iron & Steel Institute, the Knights Templars, the New York Railroad Club, the New York Athletic Club and was a Fellow of the Royal Society of Arts.

◆

O. E. Huebner, electrical engineer of Russell & Stoll Company, New York City, and an Associate of the Institute (1918) died recently. He was born in Halle, Germany, in the year 1880. Much of his later time has been devoted to research problems, the dissemination of some of his attained results being made through the columns of *Engineering News*. The pycnotic substance theory and its practical application, another of Mr. Huebner's investigations, found publicity in *Technologist*, organ of the German American Technical Societies.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the Secretary at 33 West 39th St., New York, N. Y.

Davis, R. H., Westinghouse E. & M. Co., East Pittsburgh, Pa.

Dawson, Leonard L., 98 Looker Ave., Springfield, N. J.

A. DiLucci, Box 1051, Chicago, Ill.

Gale, R. E., 706 N. 19th St., Boise, Idaho.

Charles T. Gilliam, Central Power & Light Co., Frost Nat'l. Bank Bldg., San Antonio, Tex.

Kigar, D. F., 1403 Minnie St., Port Huron, Mich.

Lieb, Adolph W., N. Y. Edison Co., 393 7th Ave., New York, N. Y.

Mahnke, E. Chris, 1400 E. 53rd St., Chicago.

Prehn, Victor N., 940 Broad St., Newark, N. J.

Sherwood, W. E., Kew Gardens, 2700 Que St. N. W., Washington, D. C.

Sliney, David, 11 Orchard St., Cranford, N. J.

Van Wyck, P. V. R., Summit, N. J.

Vreeland, F. P., 110 E. 176th St., New York.

Williams, Clifton S., Research Lab., Westinghouse E. & M. Co., East Pittsburgh, Pa.

Local Meetings

Gaseous Tubes For Illumination Purposes

On March 3, 1931, the Illumination Group of the New York Section will hold a meeting on the subject of "Gaseous Tube Lighting,"—of great interest at present when so many noteworthy developments of it have taken place within the last few months. To bring section meetings up to date on a matter which is receiving so much attention a symposium has been arranged. The three speakers all intimately connected with this phase of electrical engineering, to each present a fifteen-minute résumé accompanied by striking demonstrations; also, there will be ample opportunity for open discussion. The subjects and speakers will be as follows: "A Brief Résumé of the History of the Development of Gaseous Tube Lighting," by D. C. McFarlan Moore, consulting engineer; "High-Tension Cold Cathode Gaseous Conduction Lamps," by Leo Beck, chief engineer, Claude Neon National Laboratory; "Hot-Cathode Gaseous Conduction Lamps," by Ray D. Mailey, vice-president, General Electric Vapor Lamp Company.

The meeting will be held at 7:30 p. m. in Room 1, Fifth Floor, Engineering Societies Bldg., 33 West 39th Street, New York, N. Y.

◆

Intercommunication For Ships at Sea

The Communication Group of the New York Section will hold a meeting on the evening of March 10 for the discussion of "Communication Facilities of Ships at Sea." Two speakers have been selected to present the subject as follows: "Ship-to-Shore Radio Telephone Systems," by Frederick R. Lack, Bell Telephone Laboratories, Inc., New York, N. Y., and "Ship-to-Shore Radio Telegraph Systems," by George H. Clark of the Radio Corporation of America, New York, N. Y. There will be ample time for discussion. The meeting will be held in the auditorium of the Bell Telephone Laboratories, 55 Bethune St., (corner of West Street) New York, N. Y., and will be called to order at 7:30 p. m.

By courtesy of the Laboratories, dinner will be served in the cafeteria from 6:00 p. m. on, to members and guests at a charge of 75 cents, and during the period preceding the meeting sound pictures will be presented in the auditorium.

Developments In X-Ray Science

Dr. A. Mutscheller, director of research of the Westinghouse X-ray Company, will be the speaker at the next general meeting at the New York Section to be held at 8:15 p. m. on March 27 in the Engineering Auditorium, 33 West 39th Street, New York, N. Y.

Renowned for his contributions in the field of X-ray, Doctor Mutscheller will trace the progress from early beginnings, pointing out some of the problems which have been overcome in bringing this science up to its present highly developed state. He will describe some of the recent and outstanding accomplishments—among them the hot-cathode high vacuum valve which has made possible the generation of extremely high voltage direct current—and will discuss the various applications of the modern X-ray in the industrial and scientific world.

The lecture will be followed by a demonstration of the Lenard cathode ray tube showing some of the more spectacular results achieved today by the X-ray.

Future Section Meetings

Cleveland

March 19, 1931—Industrial Applications of Vacuum Tubes and Photoelectric Cells, by E. L. Manning, General Electric Research Laboratories, Schenectady, N. Y.

April 16, 1931—Human Relations in Industry, by Whiting Williams. Joint meeting with Student Branch of Case School of Applied Science, at which two papers will be presented by students.

Detroit-Ann Arbor

March 17, 1931—The Sound of a Shadow, by J. B. Taylor, General Electric Co.

April 21, 1931—1,000-Deg. Turbine, by Paul W. Thompson, Detroit Edison Co. Meeting to be held at the Detroit Edison Auditorium.

Lehigh Valley

March 27, 1931—Adventures in Science, by E. L. Manning. Meeting to be held at Sterling Hotel, Wilkes-Barre, Pa.

April 24, 1931—Ladies' Night, to be held at Americus Hotel, Allentown, Pa.

Niagara Frontier

March 20, 1931—Subject and speaker to be announced later.

April 17, 1931—Art of Engineering, by Mr. Dohner, Westinghouse Electric & Mfg. Co.

Seattl

March 17, 1931—Annual joint meeting of the Founders' Societies with program in charge of the American Society of Civil Engineers.

April 21, 1931—Annual joint meeting with the A. I. E. E. Student Branch of the University of Washington. Program under the auspices of the students.

Sharon

March 3, 1931—Recent Interesting Aeronautical Developments, by Lieutenant S. P. Mills, War Department, Wright Field, Dayton, Ohio.

Spokane

March 27, 1931—Program by local members as follows: Service and Services, by G. S. Covey; Standard Meter Equipment, by J. G. Finley; Relay Applications to Feeder Protection, by C. F. Norberg.

Toledo

March 20, 1931—Industrial Applications of Vacuum Tubes and Photoelectric Cells, by E. L. Manning, General Electric Laboratories, Schenectady, N. Y.

Past Section Meetings

Akron

Excitation Systems and Excitation Problems, by James F. Foote, Allied Engineers, Inc. January 8. Attendance 115.

Atlanta

The Responsibilities of the Engineers, by R. V. Wright, managing editor, *Railway Age*, and president, A. S. M. E. W. L. Stanley, Seaboard Air Line Railway, described the important problems of railroads. Joint meeting with the A. S. M. E. and A. S. C. E., preceded by dinner. February 3. Attendance 85.

Boston

Possible Application of High Tension D. C. Transmission, by H. R. Summerhayes, General Electric Co. Mr. Mr. Summerhayes outlined the development work his company is doing on thyratron tubes, and explained by the use of slides the action within the tubes and how they would be used on a transmission line. January 13. Attendance 300.

Cincinnati

George W. Bason, Condit Electrical Mfg. Corp., presented a talk on the various factors involved in circuit breaker operation. Illustrated with slides and motion pictures showing actual arc interruptions made under oil in heavy glass tanks. Dinner preceded the meeting. December 11. Attendance 102.

Cleveland

Future Power Development and Distribution in the Cleveland Metropolitan Area, by H. L. Wallau, Cleveland Electric Illuminating Co. Having described the generating equipment used by the above Company in 1901, Mr. Wallau outlined and illustrated the development and progress of the system from that period to the present day. January 22. Attendance 115.

Columbus

Some New and Interesting Developments in Engineering and Research by C. K. Lee, Westinghouse Electric & Mfg. Co. Illustrated. Also, moving pictures showing modern mechanized mining. January 31. Attendance 60.

Connecticut

Machine Switching Mechanism, by O. C. Levy, Automatic Electric, Inc. Illustrated with slides and a demonstration of the Strowger automatic telephone. Meeting held at Dunham Laboratory, Yale University. January 16. Attendance 98.

Denver

General Aspects of the Boulder Canyon Project, by E. B. Debler, U. S. Reclamation Bureau. Illustrated with lantern slides. January 16. Attendance 56.

Erie

History and Art of Paper Making, by Henry J. Obermans, Hammermill Paper Company. Many exhibits on display. December 16. Attendance 118.

Fog Flying and Development of Electrical and Magnetic Instruments for Blind Flying, by E. G. Haven, General Electric Co. Dinner in honor of the speaker preceded the meeting. January 20. Attendance 118.

Fort Wayne

Dance. January 23. Attendance 80.

Indianapolis-Lafayette

The Production of Copper, by E. S. McConnell, Anaconda Wire & Cable Co. Moving pictures showing the production of copper, starting at the mine and carrying through the various stages to the finished wire, tube, and sheet, were presented. Dinner preceded the meeting. January 23. Attendance 42.

Ithaca

Some Engineering Considerations of Talking Movie Apparatus, by Herbert Belar, R. C. A.-Victor Co. The underlying principles of sound picture systems and functions of each component part were explained in detail. January 23. Attendance 150.

Kansas City

The Engineers Place in the Community, by Rev. Earle A. Blackman, Sponsor, Kansas City Youths' Forum;

Specialty, by B. J. George, Kansas City Power & Light Co. December 23. Attendance 51.

Some Recent Developments in Lightning Protection, by I. P. Monseth, Westinghouse Electric & Mfg. Co.;

Futuristic Trend in Switchgear Equipment, by A. J. Peterson, Westinghouse Electric & Mfg. Co. Illustrated. January 28. Attendance 76.

Los Angeles

The Small but Mighty, by Dr. H. D. Arnold, Bell Telephone Laboratories, Inc. Considerable discussion followed. January 27. Attendance 271.

Madison

Symposium on Methods of Increasing the Load Factor of a Power Distribution System. Speakers—S. M. Coe, Wisconsin Power & Light Co. and Harold E. Koch, Hevi Duty Electric Co. Discussion followed. January 21. Attendance 43.

Memphis

The New City Water Works Plant, by Major Thomas H. Allen, consulting engineer. Discussion followed. January 13. Attendance 24.

Mexico

The Exploitation of Saltpeter in Chile, by E. F. Lopez, National Import Co.;

Car Lighting by Electricity in the National Railways of Mexico, by R. C. Rodriguez, National Railways of Mexico. Illustrated with charts. January 13. Attendance 41.

The Applications of Electricity in Sugar Mills, by E. I. Brown; Mental Calculations, by E. Leonarz, Jr., Mexican Light & Power Co. February 3. Attendance 34.

Milwaukee

A New System of Speed Control for A. C. Motors as Applied to Auxiliary Power Stations, by Fraser Jeffrey, Allis-

Chalmers Mfg. Co. Illustrated with slides. Discussion followed the talk. January 7. Attendance 205.

Arc Welding Generators and Their Application, by K. L. Hansen, Northwestern Mfg. Co. Mr. Hansen traced the history, application of arc welding, necessary apparatus, and latest developments in the art. Discussion followed. February 4. Attendance 53.

Minnesota

Analysis of Circuit Breakers under Short Circuit, by George W. Swallow, American Brown Boveri Co., Inc. Illustrated with motion pictures. January 28. Attendance 150.

Nebraska

The Development and Application of Radiant Energy, by T. Tennyson Harris. January 19. Attendance 25.

Oil Circuit Breaker Phenomena, by George W. Swallow, American Brown Boveri Co., Inc. February 4. Attendance 50.

Niagara Frontier

Application of Electric Power in Railroad Transportation, by S. T. Dodd, General Electric Co. Illustrated with slides and motion pictures. Informal dinner in honor of the speaker was held at the Hotel Statler. January 16. Attendance 60.

Philadelphia

Smoker at the Penn Athletic Club. February 9. Attendance 200.

Pittsburgh

Some Recent Work of the Bureau of Standards, by Dr. G. K. Burgess, Director, Bureau of Standards. Moving pictures and a demonstration of the theremin followed. Midwinter dinner meeting held jointly with the Engineers Society of Western Pennsylvania. January 13. Attendance 277.

Pittsfield

Yucatan and Its Ancient Civilization, by Colonel E. H. Thompson. Illustrated with lantern slides. January 13. Attendance 850.

Electrotherapeutics, by Dr. William Bierman, New York Physical Therapy Society. Illustrated. January 26. Attendance 175.

With Byrd to the Bottom of the World, by Dr. Laurence Gould, University of Michigan. Illustrated with moving pictures. February 3. Attendance 990.

Portland

Building of Condit—Yakima 110 Kv. Line, by C. S. Knowles, Pacific Power & Light Co.;

New Developments in High Speed Oil Circuit Breakers and Relays, by E. C. Curtis, General Electric Co. December 16. Attendance 80.

The Small but Mighty, by Dr. H. D. Arnold, Bell Telephone Laboratories, Inc. Dinner in honor of the speaker preceded the meeting. January 15. Attendance 220.

Providence

Aims and Objects of the Institute, by Professor Harold B. Smith, Worcester Polytechnic Institute. Dinner preceded the meeting. December 9. Attendance 40.

The Electrical Development of the Fifteen Mile Falls Hydroelectric Project, by E. W. Dillard, New England Power Association. Illustrated with lantern slides and motion pictures. Dinner in honor of the speaker preceded the meeting. January 7. Attendance 150.

St. Louis

Radio System of the St. Louis Police Department, by Professor R. S. Glasgow, Washington University. E. J. Bonnesen, Bell Telephone Laboratories, Inc., gave an interesting account of the new broadcast station KMOX. January 21. Attendance 180.

San Antonio

Air Conditioning of a Modern Office Building, by T. M. Cunningham, Carrier Engineering Corp. Following the address, those present inspected the air conditioning apparatus in the Milam Building. January 26. Attendance 35.

San Francisco

The Small but Mighty, by Dr. H. D. Arnold, Bell Telephone Laboratories, Inc. Illustrated. Dinner preceding the meeting held at the Engineers' Club. January 23. Attendance 450.

Seattle

The Small but Mighty, by Dr. H. D. Arnold, Bell Telephone Laboratories, Inc. January 19. Attendance 130.

Sharon

Audible Light, by John B. Taylor, General Electric Co. Demonstrations of applications of the photoelectric cell. February 3. Attendance 320.

Spokane

The Small but Mighty, by Dr. H. D. Arnold, Bell Telephone Laboratories, Inc. January 12. Attendance 200.

Syracuse

Aids to Aerial Navigation, by Charles F. Green, General Electric Co. November 17. Attendance 167.

Radiation Energy—Sun and Artificial Rays, by Paul Luckenbach, General Electric Co. January 12. Attendance 249.

Toledo

Power Transmission and High-Voltage Insulators, by A. O. Austin, Ohio Brass Co.;

Regulation on Distribution Systems, by W. T. Lowery, Toledo Edison Co. Illustrated. January 16. Attendance 90.

Toronto

Artificial Transients of Transmission Lines with Particular Reference to Performance of Lightning Arresters, by K. B. McEachron, General Electric Co. Illustrated with slides. January 23. Attendance 110.

Urbana

Physical Properties and Problems of Dielectrics, by Professor V. Karapetoff, Cornell University, and Professor J. Kunz, University of Illinois. January 13. Attendance 175.

Utah

Research Developments, by H. T. Plumb, General Electric Co. Apparatus for demonstration purposes on display. January 19. Attendance 84.

Vancouver

Practical Aspects of System Stability, by F. A. Hamilton, Jr., General Electric Co. Discussion followed. February 2. Attendance 51.

Washington

Industrial Applications of Vacuum Tubes, by E. L. Manning, General Electric Co. Mr. Manning described early and recent developments of vacuum tubes and discussed present and possible future industrial applications. Dinner in honor of the speaker held at the Cosmos Club. January 13. Attendance 249.

Cables for the Transmission of Power, by I. T. Faucett, General Cable Corp. Illustrated with slides and moving pictures. Dinner preceded the meeting. February 10. Attendance 97.

Past Branch Meetings

University of Akron

Theory and Application of Diverter Pole Generators, by N. Dickinson, Student;

Amateur Radio, by S. Liebowitz, Student. Accompanied by a demonstration of a short-wave code transmitting set. January 14. Attendance 14.

Alabama Polytechnic Institute

Oil Electric Locomotives, by K. R. Clark, Westinghouse Electric & Mfg. Co. January 8. Attendance 8.

Discussion of means to increase student participation at meetings. January 29. Attendance 7.

General discussion of Branch activities. February 5. Attendance 12.

University of Arkansas

Television, by Hugh Nelson, Student. Film—"A Tell You How Story of Telephotography." February 3. Attendance 30.

Armour Institute of Technology

Lightning Investigation on Transmission Lines, by William Drigot, Student. January 12. Attendance 38.

Illumination, by O. P. Cleaver, Westinghouse Lamp Co. Illustrated with slides. January 26. Attendance 64.

University of British Columbia

Automatic Sulphur Dioxide Testing, by M. Saunders, Student;

The Development of the Incandescent Lamp, by D. Smith, Student. Discussion followed. December 6. Attendance 10.

Inspection trip to the Haro Street substation of the B. C. Electric Railway Co. January 10. Attendance 14.

Electrical Precipitation, by E. M. Kershaw, Branch Secretary;

The Life of Michael Faraday, by E. H. Full, Student. January 20. Attendance 12.

Bucknell University

Prospective Relation of the Hoover Dam to Electrical Power, by L. H. Spangler, Student;

Faraday and His Work, by O. R. Sterling, Branch chrirman. January 19. Attendance 10.

California Institute of Technology

The Electrical Distribution System of Pasadena, by E. L. Bettanier, Pasadena Municipal Light and Power Bureau. Luncheon preceded the talk. January 23. Attendance 40.

University of California

After a discussion of Branch activities three films were presented as follows: "The Manufacture of X-ray Tubes," "Bituminous Coal," and "The Manufacture of Salt." Joint meeting with the A. S. M. E. Branch. January 28. Attendance 81.

Case School of Applied Science

Dinner meeting at which G. A. Sanow, Branch chairman, outlined the activities at the Institute's district meeting held in Philadelphia; F. A. Green spoke about the advantages of membership; and William Thomas, Instructor, discussed his experiences while employed by the General Electric Company in the Testing Department. January 8. Attendance 30.

University of Cincinnati

Michael Faraday, by Carl Heyel, Student;

Recent Trends and Developments in Power-Plant Practises, by D. Brown, Union Gas & Electric Co. Refreshments served after the meeting. February 4. Attendance 27.

Clarkson College of Technology

The Field of Chemical Engineering in Electrical Engineering, by Professor Hecker. Refreshments served. January 13. Attendance 26.

Colorado Agricultural College

Photoelectric Cell, by W. R. Carmack, Student;

Analysis of Electric Heat Treating, by L. Dougherty, Student; A. C. Holden, Student, related his experiences while employed by the Crocker-Wheeler Electric Manufacturing Co. at Ampere, N. J. January 12. Attendance 16.

University of Colorado

Talks on the Hoover Dam Project in the Colorado River Canyon, by E. B. Debler, hydrographic engineer; B. W. Steele, engineer in charge of the dam design; and L. N. McClellan, chief electrical engineer of the power plant. Meeting sponsored by the Bureau of Reclamation, U. S. Department of the Interior. Joint meeting of all engineering societies. January 7. Attendance 208.

Appraisals, by Juston H. Haynes, Lloyd-Thomas Co. January 21. Attendance 28.

Life of Faraday, by J. E. Gorochow, Student;

Life of Joseph Henry, by William Wildhack, Student;

The Thyratron, by Paul Huber, Student. Film—"Through the Oil Lands of Europe and Africa." Refreshments served. February 4. Attendance 60.

Cooper Union

Fuses, Their History, Construction, and Causes of Failure, by L. E. Edwards, Bussman Mfg. Co. January 14. Attendance 60.

Drexel Institute

Television, by E. K. Cliver, Branch Chairman. January 13. Attendance 26.

University of Florida

Operation of the Automatic Telephone, by J. L. Sanders, Student;

Electrical Equipment for Overhead Cranes, by E. Menendez, Student. February 9. Attendance 26.

Iowa State College

Business meeting. January 20. Attendance 42.

Discussion and adoption of By-laws. January 27. Attendance 21.

Televox and Electric Eye, by H. B. Stevens, Westinghouse Elec. & Mfg. Co. Joint banquet with the Iowa Section. February 6. Attendance 410.

University of Iowa

Film—"The Single Ridge." January 21. Attendance 36.

Electric Elevators, by Mr. Hathaway, Student. February 4. Attendance 46.

Kansas State College

Film—"Frozen Credits." Nomination of officers for second semester. January 15. Attendance 106.

Restoration from an Electric Shock, by L. L. Naus, U. S. Bureau of Mines. Election of officers. December 13. Attendance 69.

Lewis Institute

Business meeting. January 13. Attendance 22.

Massachusetts Institut of Technology

Inspection trip to the Edgar generating station of the Edison Electric Illuminating Co. of Boston. January 14. Attendance 40.

Michigan College of Mining and Technology

Experiences with the General Electric Company, by Mr. Howell, Instructor. Motion pictures were shown on the uses of compressed air in industry. January 14. Attendance 21.

Transformers, Their Use, and Methods of Construction, by A. G. Rogers, Student;

Substations, by W. D. Stewart, Student. January 28. Attendance 18.

Michigan State College

Short talk by Professor W. A. Murray, Counselor, on the advantages of membership in the Institute. January 8. Attendance 30.

Business meeting. January 13. Attendance 18.

Discussion of plans for the electrical show. January 27. Attendance 18.

Business discussion. February 10. Attendance 17.

University of Michigan

Power System Development, by S. M. Dean, Detroit Edison Co. January 14. Attendance 65.

School of Engineering of Milwaukee

Audio-Amplification in Public Address Systems and Broadcast Studios, by N. J. Richard, Student. Film—"Blasting the Water Highways of America." A review of business conditions of the past year was outlined by Karl Werwath, Student. January 14. Attendanc 85.

University of Minnesota

Inspection trip through the Northern States Power Company's High Bridge Plant in St. Paul. December 3. Attendance 75.

Taxation as a Measure of Valuation of a Public Utility for the Purpose of Establishing a Rate Base, by John Roe, Student;

Sale Price as a Measure of Valuation of a Public Utility for the Purpose of Establishing a Rate Base, by L. A. Rovelsky, Student. January 13. Attendance 52.

Mississippi A. & M. College

Film—"Hydroelectric Production in the New South." January 30. Attendance 61.

Missouri School of Mines and Metallurgy

Biography of Faraday, by G. L. Leisher, Student;

My Summer's Work, by M. R. James, Student. Film—"Steinmetz." January 28. Attendance 16.

University of Missouri

The Engineering Profession and the Rewards it Offers, by A. C. Lanier, head, Dept. of Elec. Eng. February 4. Attendance 28.

Montana State College

The Button Railroad, taken from *Westinghouse Magazine*, presented by M. J. Ovens, Student;

Some Technical Aspects of Sound Picture Photography, taken from Bell Laboratories Record, presented by Joseph J. Schuler, Student;

Power for Aircraft Radio, taken from *Electric Journal*, presented by M. Severud, Student. January 8. Attendance 130.

Three films presented entitled "Building New York's Newest Subway," "Hydroelectric Power Production in the New South," and "Blasting the Waterways of America." January 15. Attendance 213.

Radio Charts the Air Course, taken from *Radio News*, presented by E. J. Christiansen, Student;

Power Generation at Niagara Falls, taken from *Electric Journal*, presented by Earl Doney, Student;

Noise Measurements, taken from Electrical Engineering, presented by Frank Holly, Student;

Improving Theater Acoustics, by Joseph Hurst, Student. January 22. Attendance 131.

English for Engineers, by Paul O. Koetitz, Student;

Piezoelectric Effects, by William McKay, Student;

Vacuum Tubes Lead the Way, taken from Electrical Engineering, presented by Thomas Micka, Student. January 29. Attendance 135.

Industrial Mobilization, by Dr. Kirk, professor of chemistry. Illustrated with lantern slides. February 5. Attendance 149.

University of Nebraska

Election of officers as follows: P. Ehrenhard, chairman; W. G. Norris, vice-chairman; Walter M. Ely, secretary-treasurer. Following dinner, the students went to the Burlington Yards where Mr. Wesson, signal engineer for the C. B. & Q. Railroad, demonstrated the switching and signal system installed there. January 23. Attendance 32.

University of Nevada

Business meeting. January 7. Attendance 8.

Up-River Storage, by James Shaver, Sierra Pacific Power Co. January 14. Attendance 15.

The Operation of the Dial Telephone, by Willis Pressel, Bell Telephone Co. and senior student in Electrical Engineering. January 21. Attendance 16.

Newark College of Engineering

The Mechanical Brain, by C. H. Stephan, Student;

The Application of A. C. Rectifiers to Radio High Voltage Supplies, by A. Katz, Student. January 26. Attendance 18.

The Mercury Jet Wave Rectifier, by G. Rust, Student;

The A-C. Arc and Deion Circuit Breaker, by J. Scheid, Student;

The Earth Inductor Compass, by by C. Wayer, Student. February 9. Attendance 17.

College of the City of New York

Election of officers as follows: Charles Hachemeister, Chairman; Alex Rosenberg, vice-chairman; Howard Klein, secretary; Bernard Beaman, treasurer. January 15. Attendance 20.

New York University

Description of Apparatus and Routine in the Sherman Creek Power Plant, by J. F. Seivers, Student;

Operation of D-C. Relays, by W. J. Driver, Student;

An Acoustical Treatment of Broadcasting Studios, by M. Bogstahl, Branch Secretary;

An Original Idea in Television Scanning, by S. H. Revitz, Student;

Cables, by O. M. Lerz, Student. January 9. Attendance 17.

Business meeting. February 2. Attendance 18.

North Carolina State College

Film—"Nature's Frozen Assets." January 20. Attendance 40.

University of North Carolina

The Principle of the Three-Electrode Vacuum Tube, by Professor R. F. Stainback. Report of the Southern District Meeting at Louisville, by C. P. Hayes, Branch Representative. January 15. Attendance 33.

The Place of the Electrical Engineer in a Power Company, by P. G. Johnson, Student;

Cooperative Talk, by E. F. Frisby, Student. January 29. Attendance 29.

North Dakota State College

Film—"Conowingo." January 16. Attendance 75.

The Centennial Exposition of 1876, by F. W. Pearson, New York Life Insurance Co. Film—"Enamelware." January 28. Attendance 89.

University of North Dakota

The Effect of Lightning on Transmission Lines, by B. J. Shields, Student. Refreshments served. January 14. Attendance 20.

Election of officers as follows: B. J. Shields, chairman; Charles King, vice-chairman; Mark Scarff, secretary-treasurer. Febuary 4. Attendance 20.

Northeastern University

Construction Problems of the Fifteen-Mile Falls Development Transmission Line, by C. A. Booker, New England Power Co. Illustrated with slides. January 13. Attendance 48.

University of Notre Dame

Street Lighting and the Use of Remote Control, by Mr. Guin, South Bend Controllers Co.;

The Photoelectric Cell, by A. Petrauskas, Student;

Crosstalk and Its Elimination in Telephony, by John Perone, Student;

The Life of Ampere, by A. D. Neal, Student. Summary of news events in the electrical field was given by Patrick Murray, Student. January 12. Attendance 66.

Ohio Northern University

Automatic Train Control, by G. F. Ross, Student. January 20. Attendance 15.

Ohio State University

Synchronization of Paper Machinery, by G. E. Stoltz, Westinghouse Electric & Mfg. Company. January 15. Attendance 32.

Ohio University

A New Light-Intensity Meter, by George Wyckoff, Student;

Artificial Fever and Other Effects in the Human Body, by Herbert Adcock, Student. Film—"Arc Welding Industry." January 12. Attendance 14.

Oklahoma A. & M. College

Watt-Hour Meters, by Harold Brown, Student. January 15. Attendance 26.

University of Oklahoma

The Belle Isle Generating Station of the O. G. & E. Co., by Mr. Danner, engineer for the company. Illustrated with diagrams and slides. November 20. Attendance 51.

The Effect of Frequency Cut-Off on Sound Transmission, by Mr. Jones, Bell Telephone Co. Illustrated. January 6. Attendance 44.

Oregon State College

Business meeting. December 19. Attendance 30.

My Experiences at the Solar Observatory and Elsewhere During the Past Year, by Professor W. Weniger. January 15. Attendance 31.

Electromagnetic Light Valve and Its Application to Sound Recording, by Dale Hansen, Student;

High-Permeability Alloys, by C. Boucher, Student. February 2. Attendance 49.

University of Pittsburgh

Radio Compass, by C. W. Robinson, Student. C. H. Carroll, Student, gave a travelogue of a trip from Pittsburgh to New Orleans. December 4. Attendance 118.

A Travelogue Through China and Korea, by S. R. Staples, Westinghouse Elec. & Mfg. Co. Entertainment and refreshments followed. December 11. Attendance 76.

The History of Lighting, by D. C. Stengel, Student. E. F. Freundt, Carnegie Steel Co., reviewed power plant operation at the Homestead Steel Mill. December 18. Attendance 119.

History of the Inhabitants of Czechoslovakia, by M. Getting, Student;

Mine Laying During the World War, by O. L. Endler, Student. January 8. Attendance 111.

Two films as follows: "The Deion Breaker," and "Dynamic America." R. J. Hanna, Westinghouse Research Laboratories, demonstrated a talking motion picture projector. January 15. Attendance 85.

Modern Street Cars, by R. L. Dumeyer, Student. An explanation of the telephone typewriter was given by R. E. Morrell, Student. January 23. Attendance 114.

Pratt Institute

A discussion of the relation between education and industry was given by H. P. Miller, Instructor in Electrical Engineering. January 15. Attendance 91.

Two films presented, "New York's Newest Subway," and "Distribution of Power in the New South." January 29. Attendance 51.

Rhode Island State College

Fifteen-Mile Falls Development, by A. Galonio and J. Scussel, Students. January 19. Attendance 8.

Circuit Breakers, by L. Crandall, Student. Short business meeting followed. February 11. Attendance 13.

Rutgers University

Tendencies and Progress of Railroad Electrification in Europe Compared with American Practise, by Mr. Gelhaus, Student;

The Opportunities for Employment with the Railroads, by Mr. Jobbins, Student. December 9. Attendance 20.

Steam Generation, by Mr. Howell, Student;

Transmission and Distribution, by Mr. Trompen, Student;

The Opportunities for Employment with the Electric Light and Power Companies, by Mr. Wegel, Student. January 6. Attendance 21.

University of South Carolina

Radio Central, Rocky Point, L. I., by J. A. Kaigler, Student;

Electric Power for Cotton Mills, by H. G. Smith, Student January 12. Attendance 30.

Election of officers as follows: L. E. Rankin, chairman; C. H. Bryan, vice-chairman, L. W. Dickerson, Jr., secretary. February 9. Attendance 10.

South Dakota State School of Mines

Mr. Mitenger gave an interesting talk on his work with the Westinghouse Electric & Mfg. Co. January 22. Attendance 44.

University of Southern California

Nomination of officers. January 7. Attendance 44.

Election of officers as follows: A. E. Mathews, chairman; H. G. Cook, vice-chairman; M. C. Marshall, secretary; C. M. Drury, treasurer. January 14. Attendance 32.

A discussion of radio interference was given by A. G. Walters, Radio Trades Commission. January 21. Attendance 26.

Stanford University

Panel Type and Step-by-Step Type of Dial Telephone Systems, by W. W. Stahl, Pacific Telephone & Telegraph Co. January 15. Attendance 31.

Inspection trip through the Palo Alto exchange of the Pacific Telephone & Telegraph Co. January 17. Attendance 23.

Syracuse University

Thyratron Tubes, by Donald Robinson, Student;

Electrical Equipment in the Gypsum Industry, by Willis Kleppinger, Student. February 6. Attendance 25.

University of Tennessee

Engineering Salesmanship, by J. E. Housley, Aluminum Company of America. February 5. Attendance 18.

University of Texas

Election of officers as follows: T. E. Cole, President; C. J. Pilgrim, vice-president; J. H. Neidert, secretary-treasurer; D. Sussin, corresponding secretary. January 23. Attendance 49.

University of Vermont

Micarta Insulation, by E. V. Kibby, Student. January 13. Attendance 25.

Film—"Through the Switchboard." February 10. Attendance 33.

Virginia Polytechnic Institute

The Steinmetz that I Knew, by J. E. Birdsall, Student;

The Signal Corps Camp, by L. W. Webb, Jr., Student;

Arc Welding and Structural Steel, and, A Soundless Substation, by F. S. Boch. January 15. Attendance 31.

Business discussion. January 29. Attendance 22.

University of Virginia

G. G. Quarles, branch chairman, gave a report of the conference on Student Activities held during the Institute's Southern District meeting at Louisville, Ky. January 13. Attendance 16.

University of Washington

Film—"From Mine to Consumer." December 11. Attendance 23.

My Trip East to the Tau Beta Pi Convention, by George Palo, Student. January 8. Attendance 18.

A Year in the Frozen Arctic, by Robert J. Gleason, Student. January 15. Attendance 14.

Washington State College

Crysal Oscillators, by Lester Hatfield, Student. Duane Olney, Student, described the hydroelectric station on the Clearwater River, owned by the Pacific Power & Light Co. January 7. Attendance 24.

Washington University

L. W. Sieck, Student, gave a talk on the

St. Louis, Mo., police radio installation. January 15. Attendance 18.

West Virginia University

Business meeting. February 3. Attendance 30.

University of Wyoming

EINSTEIN'S THEORY OF RELATIVITY, by Dr. Philo F. Hammond, head of Physics Department. January 22. Attendance 37.

Yale University

TIDE WATER POWER, by H. Gears, Student;

ROCKY RIVER DEVELOPMENT OF THE CONNECTICUT LIGHT AND POWER COMPANY, by A. A. Watson, Student;

BOULDER CANYON PROJECT, by O. C. Rutledge, Student. December 9. Attendance 13.

ELECTRO-ACOUSTIC REPRODUCTION OF SOUND, by Dr. E. E. Free, Professor of General Science, N. Y. University. Joint meeting with the A. S. M. E. Branch. January 6. Attendance 66.

THE ART OF PUBLIC SPEAKING, by Professor Hubert Greaves. Illustrated. January 13. Attendance 44.

STROWGER DIAL SYSTEM, by E. Levy, Automatic Electric Company. Joint meeting with the Connecticut Section, A. I. E. E. January 16. Attendance 97.

LIGHTNING ARRESTER PROBLEMS IN DISTRIBUTION SYSTEMS, by R. Philip Hart, Cazenovia Electric & Telephone Co. January 17. Attendance 30.

A COMPREHENSIVE STUDY OF ELECTRICAL DEVELOPMENTS IN 1930, by J. N. Buckwalter, Student;

A STATISTICAL SURVEY OF ELECTRICAL INDUSTRIES IN 1930, by L. Clare, Student;

THE NATIONAL BROADCASTING NETWORK, by P. Thomson, Student;

STEEL MILLS, by R. M. Ferris, Student;

DIRECT CURRENT APPLICATION TO STEEL MILL DRIVES, by D. B. Fisk, Student;

ALTERNATING CURRENT FOR STEEL MILL DRIVES, by R. Schlitt, Student. January 20. Attendance 13.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ELECTRICAL ENGINEER, age 28; single; with considerable industrial experience; one year as graduate assistant; M. S., Iowa State College, 1930; B. S., Pennsylvania State College, 1925. Desires position as instructor, with prospect of permanent teaching position. C-3202.

ERECTING ENGINEER, 46, of broad experience in power plant construction, maintenance and operation. Exceptional ability in the erection and wiring of switchboards, power plant auxiliaries, oil circuit breakers, and high-voltage outdoor substations. Available immediately. C-8792.

HEAD OF ENGINEERING DRAWING DEPARTMENT of prominent university for seven years will consider change to similar position. Available June 1931. B. S. in electrical engineering. Telephone and electrical experience. Practical machine designer. B-8248.

1930 GRADUATE ELECTRICAL ENGINEER, University of Minnesota, age 23. Experience as a regular tester at Westinghouse Electric & Manufacturing Company. Desires position with a power company. Interested in generator or distribution work. Location, Middle West or Pacific Coast. Available now. C-8796.

ELECTRICIAN, experienced in all branches of electrical work, especially insulation application and manufacture. Capable of directing any type of electrical construction or maintenance. Considerable experience in development and application of porcelain parts. C-8769.

MECHANICAL AND ELECTRICAL ENGINEER, after thirteen years with one of the leading corporations, is now available. Experience covers all phases of design, construction, and operation of modern turbo-electric generating stations for public and private utilities, including putting existing plants in more efficient operation at moderate cost. C-8249.

GRADUATE ELECTRICAL ENGINEER, 1921. Many years' maintenance and construction work in Latin America, design and drafting experience, sound sales engineering training with G. E., fluent Spanish. Desires position along commercial or engineering lines. Preferred location, New York City or abroad. Available immediately. C-6551.

ELECTRICAL-MECHANICAL ENGINEER, married, 7 years' experience including G. E. Test, substation and distribution with utility, development with electrical manufacturer, superintendent of small shop and operation of substations and motor rooms with a steel mill. C-1063.

ELECTRICAL ENGINEER, 1930, experienced in installation, maintenance, and repair of motors as used in plants for driving industrial machinery. Have had some work on control; control of equipment for motors, on a-c. and d-c. circuits. Desires to connect with some kind of industrial equipment company. Location, immaterial. C-8763.

GRADUATE ELECTRICAL ENGINEER, 1929. One year Westinghouse Student Course. Several months' diagram and substation layout experience. Age 23, single. Location preferred, Middle West. C-8523.

ELECTRICAL ENGINEER, 1930 graduate of first-class technical school of New York State desires immediate connection. Prefers testing, research, or any other junior electrical engineering work suitable for a recent graduate. Some hydroelectric, power and lighting maintenance, construction, installation and testing before graduation. Keeping up in studies. Not interested in sales. Good references and personality. C-7936.

ELECTRICAL ENGINEER, 30, single, technical graduate, G. E. Test, ten years design and construction of substation, power plants, electrical railways and mines, five years foreign. Desires position as engineer or general foreman. Location, anywhere. Available at once. C-217.

SOUTH AMERICAN ELECTRICAL ENGINEER, 1930 graduate, 25, single. Two and one-half years' power plant experience. Desires connection with an American company. Location in any part of the States or in any Spanish speaking country. C-8766.

GRADUATE ELECTRICAL ENGINEER, 1928, single, age 25. Aggregate of two years in public utility and railway operating companies. Year Student Course, and two years railway and material handling application engineering with large manufacturer. Desires position with railway, utility, manufacturer or consulting firm. C-8671.

ELECTRICAL ENGINEER, university graduate, 44, married. Two years G. E. Test, 16 years' experience in design and manufacture of transformers with large companies. Desires position with utility or manufacturing company. Best of references. Available on short notice. C-8806.

ELECTRICAL ENGINEER, age 42. Have twenty years' experience in public utility business design, construction and operation. Also some industrial experience. With last employer twenty years. Location, immaterial. C-8798.

ELECTRICAL ENGINEER, college graduate, 31, married. Eleven years in station, transmission and distribution designs; system operation and planning; superintendence of meter and relay department; studies; reports and calculations. Good theoretical as well as practical background. Accustomed to responsibilities. Prefer New York or environs but will consider good proposition elsewhere. B-9401.

ELECTRICAL ENGINEER, graduate Sheffield Scientific School, 23 years' experience including: electrical contracting with companies doing large power work; five years in service department of large electrical manufacturing company as field engineer and supervisor. Experienced electrical estimator. Desires permanent connection, preferably in the East. C-3175.

INDUSTRIAL ENGINEER, electrical graduate, with additional study at M. I. T. Three years' manufacture and electrical test. Considerable electrical and mechanical experience relative to application of power equipment in industrial plants. Fifteen years' experience including seven years with electric utilities. Available upon short notice. Location, anywhere. A-4018.

PHYSICIST Ph. D., 39 years old, with 12 years' experience in electrical development, formerly chief of a physical laboratory, familiar with U. S. A. and foreign patent laws, desires position in electrical concern, preferably television or movietone laboratory. C-8604.

GRADUATE ELECTRICAL ENGINEER, 29, married. Two years' experience on industrial plant layout. 1½ years supervising construction jobs and one year system planning, eastern utility. Desires position where extensive accounting knowledge, acquired through night studies is an asset. Best references. Location preferred, Metropolitan New York. Available immediately. C-8535.

COLLEGE GRADUATE, 25, single, B. S. degree in E. E. Seven months R. C. A. engineering course, 11 months N. B. C. engineering course. Experience in development and research work. Seeking position in any electrical line with future and opportunity for advancement. C-8457.

ELECTRICAL ENGINEER, S. B. degree in in E. E. in 1925. Five years' experience in electrical equipment design, public utility operation and field construction. Natural writing talent. Desires work in editorial or related fields. C-4875.

WEST COAST REPRESENTATION—ELECTRICAL ENGINEER with successful selling experience, wishing to locate in Southern California, offers his services to manufacturers of products requiring a representative with engineering background. At present employed in New York City. C-1074.

WIRING DIAGRAM SPECIALIST, desires position with public utility; 43, married, technical education. Understands cooperation necessary between office and field forces in connection with wirings. Familiar with power-house and substation layouts, conduit plans, bus structures, switchboards. Experienced in drafting and its application to field work. Location preferred, East or South. C-8436.

ELECTRICAL DESIGNING ENGINEER, technical graduate, 33, expert draftsman. Power-plant, substation and illumination design experience. Two years' experience on mercury arc rectifier substations for railway service. Seeking permanent position with progressive concern. B-7332.

GRADUATE ELECTRICAL ENGINEER, single, 33. Six years with large manufacturing corporation. Experienced in manual and automatic switchgear application, preparation of specifications, testing and electrical drafting. Location, United States America. Available immediately. C-8680.

GRADUATE ELECTRICAL ENGINEER, 31, single, eight years' experience, design and construction of transmission lines, voltages up to, and including 220-kv., outdoor and indoor high-voltage substation and distribution networks. Desires position in engineering or construction department of large utility or holding company. Location, immaterial. C-3564.

ELECTRICAL DRAFTSMAN, 29, single but with dependents. Experienced on substation and power-house design, industrial and marine equipment installation. Desires temporary or permanent position. Available at at once. Location preferred, Pacific Coast. C-8729-311-C-7.

PRODUCTION MANAGER, age 49, married. Mechanical and electrical graduate. Experienced executive and organizer. Eighteen years' experience in production, maintenance, plant layout, budgeting, estimating and time study in large machinery and copper wire field. Desires a position that requires energy and initiative. Available immediately. Location preferred, immaterial. C-4440.

ELECTRICAL ENGINEER has had 8 years' experience with vacuum tube applications. Experience has covered research and development of precision laboratory apparatus. Recent activities have been centered on audio-frequency transmission circuits and design of high quality amplifiers. Inquiries invited from leading companies requiring such services with location preferably in New York. C-8745.

RAILROAD-TELEPHONE MAN, 42, married. Six years' railroad experience, 25 years' telephone experience. Desires position as foreman. Qualified to engineer layout of circuits for construction, maintenance, installation of printers, pneumatic tubes, other communication auxiliaries. Able to do Western Union Telegraph contact work, prepare close estimates and handle men. Can furnish references. C-7753.

GRADUATE ELECTRICAL ENGINEER, 28, married, American, wishes position in experimental, research or development work. Three years' experience in inspection and small instruments. Two years in accounting and statistics. B-8815.

ENGINEER, B. S. Harvard; B. S. Massachusetts Institute of Technology, mechanical and electrical engineering. Three years instructor in physics and electrical engineering. Three years drafting and design. Three and one-half years radio research and development, last two and one-half years being with R. C. A. Victor Company (Massachusetts). C-4275.

INDUSTRIAL ELECTRICAL ENGINEER, 43, over 15 years' experience on industrial plants, distribution, special applications; design, specifications, construction and maintenance. Also fire prevention and protection engineering. C-8414.

ELECTRICAL ENGINEER, 35, technical education with 10 years' executive experience supervising both design and construction. Desires position as engineer in charge of design or construction, or plant engineer. Location, immaterial. C-8683.

ELECTRICAL DESIGN DRAFTSMAN OR CHECKER, 31, single. Third year night engineering, twelve years' experience covering design of power plants, substations and network systems. Desires connection with public utility or engineering firm. Location, immaterial. Available on two weeks' notice. B-8628.

GRADUATE ELECTRICAL ENGINEER, age 25, single. Reared in the Orient, traveled widely. One year test course with motor manufacturer, one year sales experience on Pacific Coast. Desires permanent location with a company looking forward to an expansion in its foreign business. Available at once. Location, anywhere in U. S. B-6945-311-C-5-San Francisco.

MANAGER OR SUPERINTENDENT, ag 47, married. Executive, electrical or industrial. Successful organizer, efficient operator. Knows men and can handle them. Especially interested properties not now paying, where future depends on results. Reads, writes, and speaks Spanish. Capable earning six thousand up. Available, reasonly short notice. Location, preferred, not particular (Western U. S. preferred)." C-8777-312-C-1-San Francisco.

TECHNICAL GRADUATE in electrical engineering, 29, single, 1½ years' G. E. Test; over 10 years' experience with leading electrical company in repair and testing of electrical apparatus. Desires position in testing and experimental work on motors, generators, etc. Future prospects considered more important than initial salary. Best of references. C-8778.

1930 GRADUATE, ELECTRICAL ENGINEERING, 22, single. Seven months Westinghouse test. Desires position in operating or service department of utility company, but will consider work of any kind. References. Location, West or Middle west. Available at once. C-8779.

ELECTRICAL ENGINEER, 25, single. E. E. and Master's degrees. Good mathematician with theoretical and research grounding. General Electric test and general engineering courses. Interested in pure engineering, mathematics and teaching. Best references. Will consider any location. C-8382.

GRADUATE ELECTRICAL ENGINEER, 35, good technical school. Ten years' experience in electrical station construction and design drafting, including considerable mechanical experience. Latest position superintendent of design and construction of transformer substation. Preferring station design and construction with ability would consider engineering industrial plant maintenance or operation. C-8785.

ENGINEER, specially qualified in industrial construction or management in Spanish America. Twenty years' experience, design, construction, management, sales, more than two-thirds in United States. Unusually fluent, correct Spanish. Large acquaintance officials, industry, South America, especially West Coast.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
A. K. Krauser, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Would take a contract, branch managership, or sales agency part commission basis, any engineering line, states or abroad. C-8822.

SWITCHBOARD FOREMAN, age 31, married, four years with Western Electric Company. Six years with construction companies for public utilities, specializing in installation of switchboards and control apparatus for power houses and substations. Also experience in metallic telephone and carrier current telephone installation. C-4831.

ELECTRICAL ENGINEER, 27, single. Experience with public utility company in transmission, distribution (overhead and underground), and substation design and construction. Two years design on motor installations and power-plant equipment with nationally known engineering corporation. Desires connection with engineering department of public utility company in West or Middle West. C-8541.

ELECTRICAL ENGINEER, 24, single. B. S. in E. E. Westinghouse graduate student course. Twenty-one months' experience, design and application of railway control apparatus. Also some experience as student engineer, large power company. Desires position with opportunity for advancement with railway operating company, other utility, manufacturing company. Location preferred, East, Middle West. C-8742.

ELECTRICAL ENGINEER, B. S. degree in 1919; age 33, married. Ten years' experience with large company making electrical power apparatus, includes designing of electrical and mechanical construction and calculating of cost, weight and dimensions, in connection with customers' negotiations. Available at once. Location, immaterial. C-4633.

ELECTRICAL ENGINEER, 24, married. Desires engineering work. Has had experience with oscillographs and radio. Holds second-grade commercial wireless operators license. Has public utility test experience. Also surveying experience. Personal interview desired. C-8035.

GRADUATE ELECTRICAL ENGINEER, 30, married. Practical experience in design and construction of industrial equipment and lighting layouts; electric overhead and underground distribution with traction utility; electric and general contracting in own business. Available immediately. B-6384.

GRADUATE ELECTRICAL ENGINEER, 28, four years' manufacturing experience in production and engineering on electrical motors, desires position with company where greater opportunities are offered. C-2882.

Membership

Transfers Recommended

The Board of Examiners, at its meeting of February 18, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grad of Fellow

CHURCHWARD, ALEXANDER, Technical Director, Wilson Welder & Metals Co., North Bergen, N. J.

HARRISON, WILLIAM H., plant engineer, American Tel. & Tel. Co., New York.

JOHNSON, F. ELLIS, head of Dept. of Elec. Engg., Iowa State College, Ames, Iowa.

MELVIN, HOWARD L., assistant electrical Engr., Electric Bond & Share Co., New York.

SILLCOX, LEWIS K., vice-president, New York Air Brake Co., Watertown, N. Y.

To Grad of Member

ABBOTT, THOMAS A., instructor in Elec. Engg., Yale University, New Haven, Conn.

AYRES, EDMUND D., Asst. Prof. of Elec. Engg., University of Wisconsin, Madison, Wis.

BRAATEN, THEODORE, Switchgear Engineer, Westinghouse Elec. & Mfg. Co., Boston, Mass.

BROWN, JOSEPH S., engineer, Stone & Webster Engg. Corp., Boston, Mass.

BURTON, JAMES A., telephone & telegraph engr., American Tel. & Tel. Co., New York.

COWGILL, LESTER B., asst. engr., Electric Bond & Share Co., New York.

FARRINGTON, JOHN F., radio engr., International Communications Labs., New York.

HAGAN, JAMES S., elec. engr., Central Railroad Co. of New Jersey, Jersey City Terminal, N. J.

HENDRICKS, CHESTER I., Plant Engr., Texas Electric Service Co., Fort Worth, Texas.

HUTTON, LESLIE B., chief engr., Southland Electric Power Board, Invercargill, N. Z.

JORDON, CHARLES A., asst. engr., Electric Bond & Share Co., New York.

PIERCE, ROBERT E., asst. engr., Electric Bond & Share Co., New York.

SCHWAGER, A. C., oil circuit breaker design engr., Pacific Electric Mfg. Corp., San Francisco, Calif.

SQUIRES, HOWARD A., district manager, Delta-Star Electric Co., and Champion Switch Co., Boston, Mass.

VAN DYCK, WILLIAM VAN BERGEN, manager, International General Electric Co. Inc., Schenectady, N. Y.

WRIGHT, ERNEST M., asst. engr., Pacific Gas & Elec. Co., San Francisco, Calif.

◆

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before March 31, 1931.

Abeel, L. B., Tonawanda Power Co., North Tonawanda, N. Y.

Amick, W. M., Western Electric Co., Inc., Newark, N. J.

Anderson, E. G., General Electric Co., Fort Wayne, Ind.

Babbitt, G. W., Canadian & General Finance Co., Toronto, Ont., Can.

Bairos, C. A., Stanford University, Stanford University, Calif.

Barnett, F. G. (Member), Rockford Electric Co., Rockford, Ill.

Becker, A. J., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.

Berlin, J. A. W., International Harvester Co., Chicago, Ill.

Blocksom, F. C., United States Bureau of Mines, Denver, Colo.

Boicourt, F. R., Iowa Public Service Co., Storm Lake, Iowa

Breece, C. A., Indiana Bell Tel. Co., Indianapolis, Ind.

Butler, J. W., General Electric Co., Schenectady, N. Y.

Campbell, G. H., General Electric Co., New York, N. Y.

Clutts, C. E., American Tel. & Tel. Co., New York, N. Y.

Cole, C. S., Copper & Brass Research Association, New York, N. Y.

Compton, K. T., (Fellow), Mass. Inst. of Technology, Cambridge, Mass.

Crary, S. B., Jr., General Electric Co., Schenectady, N. Y.

Cyr, A. J., New Brunswick Electric Power Comm., St. John, N. B., Can.

David, A. R., Brooklyn Edison Co., Brooklyn, N. Y.

Deavers, W. R., Virginia Electric & Power Co., Richmond, Va.

Diaz, M. S., Allis-Chalmers Mfg. Co., West Allis, Wis.

Dorman, B. H., General Electric Co., Buffalo, N. Y.

Elder, T. W., The Ohio Power Co., Coshocton, Ohio

Erskine, S. E., Canadian General Electric Co., Vancouver, B. C., Can.

Fife, W. H., United Electric Light & Power Co., New York, N. Y.

Foos, C. B., General Electric Co., Schenectady, N. Y.

Fountain, L. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Franzen, J. E., Management Engg. Corp., Indianapolis, Ind.

Geer, A. L., Shell Pipe Line Corp., Colorado, Tex.

Gosinski, J. N., Allied Engineers, Inc., Jackson, Mich.

Goslin, R. A., Fairbanks-Morse & Co., Indianapolis, Ind.

Haege, O. C., E. J. Cheney, New York, N. Y.

Hamner, F. G., Allied Engineers, Inc., Birmingham, Ala.

Hansen, P., Western Union Telegraph Co., New York, N. Y.

Haynes, H. H., 59 Hilltop Drive, Nichols, Bridgeport, Conn.

Heiser, C. A., Anaconda Wire & Cable Co., Dallas, Tex.

Henderson, F. M., Indiana & Michigan Electric Co., South Bend, Ind.

Herrington, L. B., Kentucky Utilities Co., Louisville, Ky.

Hitchcock, R. C., (Member), Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Hively, J. P. H., General Electric Co., Schenectady, N. Y.

Holper, P. E., Western Electric Co., Kearny, N. J.

Holzman, W. H., 245-29th St., Oakland, Calif.

Horan, T. I., Pennsylvania Power & Light Co., Danvill , Pa.

Hutcheson, R. M., Virginia Electric & Power Co., Richmond, Va.
Ikola, G. H., Carnegie Institute of Technology, Pittsburgh, Pa.
Johnson, H. D., General Electric Co., Schenectady, N. Y.
Kilgen, G. J., Jr., New Jersey Public Service Electric & Gas Co., Newark, N. J.
Knaus, W. L., General Electric Co., Schenectady, N. Y.
Koontz, L. F., General Electric Co., Schenectady, N. Y.
Kramer, E. M., Electric Service Supplies Co., Philadelphia, Pa.
Krieger, H. R., Consolidated Gas Electric Light & Power Co., Baltimore, Md.
Kuhn, R. J., (Member), New Orleans Public Service Co., Inc., New Orleans, La.
Leiendecker, J. A., National Lumber & Creosoting Co., Dallas, Tex.
Lilja, E. D., Barber-Colman Co., Rockford, Ill.
Lintern, F. S., Cleveland Railway Co., Cleveland, Ohio
Lloyd, C. I., Western Electric Co., Kearny, N. J.
Lusher, W. R., Hydro-Electric Power Comm. of Ontario, Toronto, Ont., Can.
MacLaren, I. W., University of Kansas, Lawrence, Kans.
Mahr, A., (Member), Central States Pr. & Lt. Corp; Missouri Elec. Pr. Co., Mountain Grove, Mo.
Maibauer, A. E., The Bakelite Corp., Bloomfield, N. J.
Mann, J., Metropolitan Device Corp., Brooklyn, N. Y.
Mason, W. C., General Electric Co., Schenectady, N. Y.
Maynard, S. J., Valley Electric Service Co., Bay City, Mich.
McCanne, L., Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.
McClintock, W. E., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
McConnell, J. D., W. S. Lee Engineering Corp., Charlotte, N. C.
McMillan, R. W., Jr., Pennsylvania Power & Light Co., Allentown, Pa.
McNeil, D. H., Stone & Webster, Inc., Washington, D. C.
McNellis, B., 545 W. 111th St., New York, N. Y.
Meixell, O. S., Western Electric Co., Kearny, N. J.
Mendenhall, V. D., General Electric Co., Philadelphia, Pa.
Mennie, J. H., Western Electric Co., Kearny, N. J.
Merkel, C. O., Edge Moor Iron Co., Edge Moor, Del.
Mirk, D., Moccasin Power House, City of San Francisco, Moccasin, Calif.
Mole, J. R., (Member), Asbestos Corp., Ltd., Thetford Mines, Que., Can.
Moore, F. B., Erie Electric Sales & Service, Inc., Erie, Pa.
Moore, H., Jr., Public Service Co. of Colo., Denver, Colo.
Mowat, G., Pacific Gas & Electric Co., San Francisco, Calif.
Nash, E., D. L. & W. Railroad, Hoboken, N. J.
Nudd, P., General Electric Co., Schenectady, N. Y.
Olson, R. C., Cleveland Railway Co., Cleveland, Ohio
Parker, N., Climax Molybdenum Co., Climax, Colo.
Pierson, A. R., Jr., Moloney Electric Co., Atlanta, Ga.
Pollock, M. W., (Member), Cia. Hidroelectrica Guanajuatense, S. A., Mexico, D. F., Mexico
Purrington, T. U., Western Electric Co., Kearny, N. J.
Rainey, M., National Electric Light Association, New York, N. Y.
Raney, W. E., The Colonial Electric Co., Cleveland, Ohio
Rawls, J. A., Virginia Electric & Power Co., Richmond, Va.
Reiter, R., General Electric Co., Schenectady, N. Y.
Ripley, H. C., 18 Virginia St., Milton, Mass.
Runaldue, L. R., General Electric Co., Schenectady, N. Y.
Savage, P. L., General Electric Co., Los Angeles, Calif.
Scampton, W. D., Canadian Utilities Ltd., Nokomis, Sask., Can.
SeLegue, J. B., General Electric Co., Los Angeles, Calif.
Shaw, T. E., Homestake Mining Co., Lead, So Dak.
Shriber, A. L., Dept. of Water & Power, City of Los Angeles, Los Angeles, Calif.
Shuman, M. M. (Member), Virginia Public Service Co., Alexandria, Va.
Small, T. M., Ludlow Manufacturing Associates, Ludlow, Mass.
Smith, H. P., Fairbanks-Morse & Co., Chicago, Ill.
Spatz, W. C., American Tel. & Tel. Co., Richmond, Va.
Specht, W., General Electric Co., Philadelphia, Pa.
Stinson, W. L., (Member), Jeffery Dewitt Insulator Co., New York, N. Y.
Stokes, H. L., University of South Carolina, Columbia, S. C.
Stromsted, A. J., Fuller & McClintock, New York, N. Y.
Stulginskis, B. A., D. P. Robinson & Co., Inc., Trona, Calif.
Sullivan, E. S., The Home Tel. & Tel. Co., Fort Wayne, Ind.
Thomas, M. A., University of Texas, Austin, Tex.
Thuem, C. H., General Electric Co., New York, N. Y.
Titherington, R. G., General Electric Co., Shreveport, La.
Waggoner, E. M., 2 Cannon St., Poughkeepsie, N. Y.
Wang, C. C., 103 E. Oak St., West Lafayette, Indiana
Ware, R. L., Virginia Electric & Power Co., Richmond, Va.
Wasson, O., General Electric Co., Philadelphia, Pa.
Weyerts, E. E., General Electric Co., Tacoma, Wash.
Wilson, J. M., Hydro-Electric Power Comm. of Ontario, Niagara Falls, Ont., Can.
Wolf, H., College of the City of New York, New York, N. Y.
Wong, C. L., 2017 W. Monroe St., Chicago, Ill.
Total 127

Foreign

Ball, R. D., English Electric Co., Ltd., Bradford, Eng.
Bawa, S. K., (Member), Public Works Dept., Lahore, Punjab, India
Cunningham, B. T., Taikoo Sugar Refining Co. Ltd., Hongkong, China
Cuthbertson, R. M., L. J. Reynolds, Carrington Chambers, Sydney, N. S. W., Australia
Kemp, R. C., Santa Marta Railway Co., Ltd., Santa Marta, Colombia, South America
Mehta, M. L., Delhi Cloth & General Mills Co., Ltd., Delhi, India
Mistry, K. B., (Member), Public Works Dept., Bombay, India
Sandoval, F., (Member), Chilean State Railways, Santiago, Chile
Shen, P., Chinese Government Radio Administration, Shanghai, China
Tsao, T. C., University of Chekiang, Hangchow, China
Wadadekar, S. V., The Dharwar Electric Supply Co., Ltd., Dharwar, India
Total 11

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during January are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

INDUSTRIAL HISTORY OF THE UNITED STATES. By Witt Bowden. N. Y., Adelphi Company, 1930. 511 pp., 8 x 6 in., cloth. $4.00.——A very readable one-volume account of our industrial growth from the period of discovery to the present day. The economic forces governing each epoch are clearly indicated and their influence upon our industrial development shown. The general reader as well as the student will find the book of interest.

TELEPHONE THEORY AND PRACTICE, v. 1; Theory and Elements. By Kempster B. Miller. N. Y., McGraw-Hill Book Co., 1930. 486 pp., illus., diagrs., 9 x 6 in., cloth. $5.00.——This is the first volume of a three-volume text which is intended to give students and advanced workers a comprehensive review of modern telephony. The book is the successor of the author's "American Telephone Practice," but is entirely new.

The present volume relates to the underlying theory. An introductory general and historical section is followed by a discussion of acoustical and electrical principles. The elements of telephone apparatus are then treated. The work is non-mathematical and descriptive.

AMBER TO AMPERES; the Story of Electricity. By Ernest Greenwood. N. Y., Harper & Bros., 1931. 332 pp., illus., ports., 10 x 6 in., cloth. $4.00.——Sketches the growth of our knowledge and use of electricity from the earliest times to the present day. The author's method has been to select the principal events in the progress of the science and to present an account of the social and historical background of each and of the chief personalities involved. The uses of electricity for illumination and communication are emphasized in this interesting work.

Drehstrommotoren mit Doppelkäfiganker und Verwandte Konstruktionen. By Franklin Punga and Otto Raydt. Berlin, Julius Springer, 1931. 165 pp., illus., diagrs., 9 x 6 in., bound. 16.-r. m.——Discusses the design and construction of these motors, explains their advantages and describes the more important commercial types. A section is devoted also to centrifugal couplings.

The Dynamic Universe. By James Mackaye. N. Y., Charles Scribner's Sons, 1931. 308 pp., 8 x 6 in., cloth. $3.50.——This book presents a radiational theory of the structure of matter and the cause of its change of motion. The theory is physical, rather than mathematical or metaphysical. It aims, while accepting Einstein's equations, to give an explanation and reinterpretation of them which will be more natural. An important contribution to theoretical physics.

An Early Experiment in Industrial Organization; being a history of the firm of Boulton & Watt, 1775-1805. By Erich Roll. Lond. & N. Y., Longmans, Green & Co., 1930. 320 pp., plate, 9 x 6 in., cloth. $5.00——An interesting study of the organization of the earliest engineering factory, and of the business methods adopted in its management. The rapid development of the business is traced in detail, and its business organization and policy, wage system, relations with labor, and similar problems are discussed. The point of view is entirely economic.

Electrical Equipment. By T. C. Lloyd. N. Y., John Wiley & Sons, 1930. 287 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.50.——Intended for students of mining, mechanical and chemical engineering who have studied the theory of the motor, generator, and transformer, and wish a brief account of the theory of a wider variety of electrical equipment, as a guide to the selection of apparatus for given requirements. In addition to the fundamental machines, the author discusses switchboards, meters, storage batteries, illumination, heating, transmission, distribution, and rectification. Comparative cost data are given, and economic questions discussed.

Electroplating; a Survey of Modern Practise. By Samuel Field and A. Dudley Weill. N. Y., Isaac Pitman & Sons, 1930. 205 pp., illus., tables, 8 x 5 in., cloth. $2.00.——A concise treatise which brings together the results of modern research for the practical electroplater.

Guide du Technicien pour l'Organisation du Travail Personnel. By J. Rousset. Paris, Ch. Béranger, 1930. 192 pp., illus., 10 x 6 in., cloth. 62,50 fr.——This unusual book is a guide to the collection and utilization of information, for the benefit of engineers. The author discusses the collection and classification of notes and documents, the organization of libraries, the use of reference libraries, the writing of articles, book publishing and a number of related topics. Much practical, sound advice not collected elsewhere is given.

Magnetic Phenomena. By Samuel Robinson Williams. N. Y., McGraw-Hill Book Co., 1931. (International Series in Physics). 230 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.00.——A general survey of the whole field, intended to stimulate interest in research work in magnetism and to give the preparatory background for it. The theory of magnetism and the effects of magnetism upon the mechanical, acoustical, electrical, thermal and optical properties of matter are presented.

The Quantam Theory. By Fritz Reiche; translated by H. S. Hatfield and Henry L. Brose. N. Y., E. P. Dutton & Co., 1930. 218 pp., 8 x 5 in., cloth. $2.10.——An excellent account of the origin and development of the quantum theory from its introduction to the present day, which does not make any great mathematical demands upon the reader. A bibliography and numerous references furnish ample guidance to students who wish to pursue the subject further.

Relaisbuch. By Vereinigung der Elektrizitätswerke. Berlin, The Association, 1930. 457 pp., illus., diagrs., plates, 8 x 6 in., cloth. Price not indicated.——A handbook for operators in electric power stations and electrically equipped industrial plants, upon the practical use of protective relays. The protective systems in use, their application under various conditions, the accessories of relay systems, and the methods of testing relays are discussed fully and practically. The book is published by the Association of Electric Plants of Germany.

Richtlinien für Geschweisste Gasrohrleitungen von mehr als 200 mm Durchmesser und mehr als 1 atü Betriebsdruck. Berlin, V. D. I. Verlag 1930. 10 pp., 8 x 6 in., paper. Price not indicated.——Specifications for welding gas mains, approved by the Standards Committee of the Society of German Engineers.

Die Röntgentechnik in der Materialprüfung. By J. Eggert and E. Schiebold. (Ergebnisse der technischen Röntgenkunde, bd. 1). Leipzig, Akademische Verlagsgesellschaft, 1930. 206 pp., illus., diagrs., 9 x 6 in., cloth. 16,80 r. m.——Contains a course of lectures delivered by various specialists at the Charlottenburg Technical High School. These describe the principles of Roentgenology, the apparatus and methods used, and the ways in which X-rays are used to detect flaws in castings and welds, in chemical engineering, and in other branches of manufacturing. Much practical information is given.

Text-Book of Practical Physical Chemistry. By K. Fajans and J. Wüst. N. Y., E. P. Dutton & Co., 1930. 233 pp., illus., 9 x 6 in., cloth. $4.95.——A laboratory textbook, giving detailed directions for performing experiments that illustrate the chief methods of physicochemical investigation. The theory of each experiment is also explained.

Treatise on Physical Chemistry. Edited by Hugh S. Taylor. 2nd edition. N. Y., D. Van Nostrand Company, 1931. 2 v., illus., diagrs., tables, 9 x 6 in., fabrikoid. $15.00 (2 v.).——Intended to present modern physical chemistry with sufficient comprehensiveness to meet the needs of advanced students and of men engaged in industrial research who wish the theoretical treatment of their investigations. The work is the joint effort of a group of eminent authorities and is a most satisfactory treatise.

The new edition has been extensively revised to include recent developments.

Verdampfen Kondensieren und Kühlen. By E. Hausbrand. 7th edition revised by M. Hirsch. Berlin, Julius Springer, 1931. 359 pp., illus., diagrs., 9 x 6 in., cloth. 29.-r. m.——Although issued as a new edition of Hausbrand's well-known work, this is practically a new book. To a larger extent than formerly, the theoretical principles are presented. Formulas and graphs replace many tables of numerical data. The technique of evaporating has been made the principal topic, and condensing and cooling are considered only in relation to evaporating plants.

The new work treats the subject much more systematically and scientifically. The data required by the designer are given extensive discussion, and the construction and use of evaporating apparatus are treated.

Vollständige Zahlentafel und Diagramme für das Spezifische Volumen des Wasserdampfes bei Drücken zwischen 1 und 270 at. By H. Speyerer and G. Sauer. Berlin, V. D. I. Verlag, 1930. 8 pp., 8 x 12 in., paper. 2,50 r. m.——These tables are based on the data of Knoblauch, Raisch, Hausen, Davis and Smith. The tables extend from 100 deg. cent. to 550 deg., by ten-degree intervals. Values are given for each atmosphere below 120, and for each five atmospheres for higher pressures.

Engineering Societies Library

29 West 39th Street, New York, N. Y.

Maintained as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Selected Items *From* Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Accidents

ELECTRIC. Electric Shock: Interpretation of Field Notes, W. Maclachlan. *Hydro-Electric Power Commission of Ontario—Bul.*, vol. 17, no. 11, Nov. 1930, pp. 418-427, 2 figs. Analysis, of reports of approximately 700 cases of electric accidents.

Arcs

ELECTRIC. Some Causes for Variations in the Light and Steadiness of High Intensity Carbons, D. B. Joy and A. C. Downes. *Soc. Motion Picture Engrs.—Jl.*, vol 16, no. 1, Jan. 1931, pp. 61-65 and (discussion) 65-66, 3 figs. Arc length-arc voltage relations of high intensity arc depend very largely upon relative positions of positive and negative carbons; there is very definite point at which light is maximum and point of maximum light is not point of maximum steadiness. Bibliography.

Busbars

LOSSES. The Efficient Utilization of Conductor Material in Busbar Sections, O. Dannatt and S. W. Redfearn. *World Power* (*Lond.*), vol. 14, nos. 83 and 84, Nov. 1930, pp. 397-400 and Dec., pp 492-496, 8 figs. Nov.: Main factors determining conductor losses in a.c. busbar systems and influence of their distribution on temperature rises obtained; extent to which theoretical solutions are available for predetermination of temperature rise. Dec.: Experimental methods for measurement of total loss.

Cables

DESTRUCTION BY INSECTS. Beetle Damage to Lead Cable, E. J. P. Rendell. *Elec. Light and Power*, vol. 8, no. 12, Dec. 1930, pp. 70, 72 and 74, 5 figs. Cases of damage to aerial telephone cables by lead boring insects have been reported from varied parts of world; matters have been investigated by Government scientists whose findings are set forth in bulletin No. 1107 issued by Department of Agriculture; experiments of Pernambuco are related. Abstract of paper in Proc. of Entomological Soc. of Washington.

FUSE BOXES. Network Boxes. *Engineer* (*Lond.*), vol. 150, no. 3908, Dec. 5, 1930, p. 622, 1 fig. New type of link or fuse disconnecting box for four or five-core cables put on market by British Insulated Cables, Ltd.; all current-carrying parts are made from high-conductivity copper strip, and number of joints or contacts has been reduced to minimum; links are of plug type, with volted contacts.

GROUNDS. Freak Earth Faults, H. Joseph. *Elec. Times* (*Lond.*), vol. 78, no. 2042, Dec. 11, 1930, p. 1019, 3 figs. Analysis of potential differences which even may lead to shock set up in ground near grounded conductor of underground cable.

IMPREGNATING MATERIALS. Weatherproof Impregnated braided Insulation of Electric Lines (Wetterfest getraenkte Beflechtungen von elektrischen Leitungen), E. Kindscher. *Gummi-Zeitung* (*Berlin*), vol. 45, no. 9, Nov. 12, 1930, pp. 333-336. Laufenberg and others have shown increasing water impermeability of films with increasing content of organically bound lead; author's tests in Government experimental station in Berlin-Dahlem to ascertain cause of varying behavior of red-lead linseed-oil mixtures; necessity is shown of careful selection of specially suitable red lead for impregnated cables, such as will improve action of linseed oil by formation of organic lead compounds.

TELEGRAPH, TRANSATLANTIC. Advances in Transoceanic Cable Technique, H. Mason. *Inst. Radio Engrs.—Proc.*, vol. 18, no. 12, Dec. 1930, pp. 2176-2191, 3 figs. Progress in construction of transatlantic cables is described from earliest to most recent type, which operates at 1400 letters per min. without technical detail development of cable operating mechanisms is sketched indicating improvement which resulted from use of relays, magnifiers, and regenerators; application to cable art of land-line multiplex telegraph practice is shown.

TESTING. Portable Kenetron Housing Design, C. W. Evans. *Elec. World*, vol. 96, no. 26, Dec. 27, 1930, pp. 1178, 1 fig. Design is for 100-kv. cable testing set and it contains every facility for rapid routine testing; frame work is 2 by 4-in. scantling and roof and sides are of shiplap; floor is of 1 by 8-in. boards, and frame is assembled with bolts and screws.

PAPER INSULATED. Reduces Cable Ionization by Super-Vacuum Process, S. J. Rosch and H. G. Burd. *Elec. World*, vol. 96, no. 25, Dec. 20, 1930, pp., 1132-1135, 7 figs. For one year process has been used at Hastings-on-Hudson plant of Anaconda Wire & Cable Co., that has been particularly effective in removing occluded gases and moisture from compound and paper insulation before it is impregnated in preventing contamination between steps in process, with result that very low power factor is obtained even at high unit stresses.

RADIO INTERFERENCE. Simultaneous Atmospheric and Cable Interference (Gleichzeitige Luft-und Kabelstoerungen), M. Baeumler. *Elektrische Nachrichten-Technik* (*Berlin*), vol. 7, no. 8, Aug. 1930, pp. 325-330, 15 figs. Report on measurements by Haak and O. Fuchs on simple wire Emden-Vigo cable in order to study simultaneous occurrence of interference in cable and in ether.

SUBMARINE INSULATION. Paragutta, A New Insulating Material for Submarine Cables, A. R. Kemp. *Franklin Inst.—Jl.*, vol. 211, no. 1, Jan. 1931, pp. 37-57, 9 figs. Extended study was undertaken of causes of losses and other electrical weaknesses of submarine insulation and search has been made for better materials; as result of this investigation insulation called paragutta has been developed which as name suggests is derived essentially from rubber and gutta percha. Bibliography.

Circuit Breakers

OIL. Modern Switchgear. *Engineer* (*Lond.*) vol. 150, no. 3910, Dec. 19, 1930, pp. 674-675, 7 figs. Type RM circuit breaker rated at 4000 amperes at 12,000 volts with breaking capacity of 1,000,000 kva, this being, it is said, largest horizontal draw-out metal-clad switchgear unit that has been built; special feature of new Reyrolle type is complete separation of phases in circuit-breaker portion of gear.

Commutators

FAILURE. Oil Seepage Causes Commutator Failures, W. O. Hurlburt. *Elec. West*, vol. 66, no. 1, Jan. 1, 1931, pp. 24-25, 3 figs. Systematic recording and observation of commutator failures has led to conclusion that in majority of cases, primary cause of breakdowns can be attributed to seepage of oil from bearings; most records were made from motors in elevator service subjected to rotation reversal, although unidirectional machines showed identical tendencies.

Condensers

SYNCHRONOUS. Synchronous Condensers and Capacitors. *Power Plant Eng.*, vol. 35, no. 1, Jan. 1, 1931, pp. 93-94, 4 figs. Correction of low power factor by means of synchronous or static condensers.

Conductors

ELECTRIC. Control Contacts and Arc Lengths, W. B. Kindy. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 727-728, 2 figs. Characteristics of arc which is drawn when low capacity, low-voltage, d.c. circuit is opened by set of contacts in design of control circuits of modern automatic and remotely controlled electrical equipment, are discussed.

ALUMINUM. The Jointing of Steel Cored Aluminum Conductors. *Engineer* (*Lond.*), vol. 150, no. 3910, Dec 19, 1930, p. 688. Tests have been made at Prescot Works of British Insulated Cables, Ltd., on firm's patented aerial cable union, and tests show that this type of joint complies fully with requirements.

INSULATION. Ueber die Beflechtung isolierter Leitungen (Braiding of Insulated Wire) K. Sieber. *V. D. I. Zeit.*, vol. 74, no. 51, Dec. 20, 1930, pp. 1735-1738, 7 figs. Influence of thickness of braid and of braiding angle on quality and costs of braiding: mathematical analysis of braid thickness, braiding costs, etc.

LIQUID. New Experiment for Demonstrating the "Pinch" Effect (Ein neuer Versuch zur Demonstration des "Pinch" Effektes), E. Blaich. *Elektrotechnik und Maschinenbau* (*Vienna*), vol. 48, no. 49, Dec. 7, 1930, pp. 1083-1085, 4 figs. Experiment which shows that motions in liquid conductors, as noticed for instance in induction furnace, find their principal cause in electromagnetic processes.

Control

REGENERATIVE. Regenerative Control with Compound Motors on Paris Tramways, M. Bacqueyrisse. *Tramway and Ry. World.* (*Lond.*), vol. 68, no. 24, Nov. 13, 1930, pp. 275-281 and (discussion) 281-283, 11 figs.; see also editorial comment on p. 274. Design principles, simplification and improvements of regenerative control equipment; permanent coupling of motors; abolition of series-parallel transition; arrangement of motors in series; controller of reduced size; traction equipment with compound motors built by Alsthom Company, for "L" type cars on Paris street railroad two and three-car trains. Paper read before International Tramways and Light Rys. Union, Paris.

Regenerative Control with Compound Wound Motors (Stromrueckgewunnung mit Verbundmotoren), W. Mattersdorff. *Verkehrstechnik* (*Berlin*), no. 50, Dec. 12, 1930, pp. 657-660, 3 figs. Results obtained at Session of Internationaler Strassenbahn and Kleinbahnverein, October 1930, in Paris with respect to problem; various systems of regenerative control; Bacqueyrisse connection.

Controllers

ELECTRIC. Electrical Control Gear. *Engineer* (*Lond.*), vol. 150, no. 3911, Dec 26, 1930, pp. 714-715, 4 figs. Control gear made by Laurence, Scott, and Electromotors, Ltd. for machines intended for balancing large turbine rotors weighing 17 tons or more; gear of this type has been supplied to Royal dockyards and to several private shipyards.

Converters

FREQUENCY. Frequency Converters for A. C. Railroad Electrification, L. G. Smith. *Nat. Elec. Light Assn.—Bul.* vol. 17, no. 12, Dec. 1930, pp. 755-757, 6 figs. How to meet problem of single phase electrification; types of converters available; factors to consider in selection; design features of single phase generators; types of phase balances available; comparative costs and losses.

Cranes

ELECTRIC. Repulsion Motor as Crane Motor (Der staendergespeiste Einphasenkommutatormotor (Repulsionsmotor) als Kranmotor), R. Richter. *Foerdertechnik und Frachtverkehr* (*Wittenberg*), vol. 23, no. 23 and 26, Nov. 7, 1930, pp. 439-443, and Dec. 19, pp. 494-497, 6 figs. Nov. 7: Tests made on portal crane which has four repulsion motors, for hoisting, slewing, crane travel on portal and portal travel, show that for alternating current, these motors are well suited as crane motors; description of crane and result of tests with hoisting motor; Dec. 19: Result of tests with slewing and travel motors; operation characteristics and construction of one phase repulsion motors.

Diesel-Electric Plants

Practical Building Pointers for Diesel Engine Plants. *Diesel Power*, vol. 8, no. 12, Dec. 1930, pp. 632-634, 2 figs. Plan of plant designed to avoid wasting building volume on accessories.

COSTS. Operating Cost of Diesel Engine (Sul costo di esercizio dei motori Diesel), G. Colajanni. *Energia Elettrica* (*Milan*), vol. 7, no. 10, Oct. 1930, pp. 864-866. Review of relative importance of various items of operating expenses based on Italian experiences.

GREAT BRITAIN. An Oil-Engined Central Station. *Power Engr.* (*Lond.*), vol. 25, no. 297, Dec. 1930, pp. 461-465, 8 figs. Layout and constructional features of Dunoon electricity undertaking; main engines supplied by Davey Paxman & Co., Ltd.; 5-cylinder sets developing 345 b. hp. at 300 r. p. m.; vertical 4-stroke cold-starting Diesel engine with patent spring-injection systems for fuel admission; cooling water system and auxiliary plant; electrical system.

SLATER, MO. High Cost of Smoke and Cinders Cut by Slater, Mo., Diesels, R. R. Howard. *Diesel Power*, vol. 8, no. 12, Dec. 1930, pp. 618-620, 3 figs. Plant equipped with five totalling 1500 hp., each complete with engine, alternator, exciter, and switchboard panel with voltmeter, ammeters, indicating kilowatt meter and totalizing kilowatt-hour meter.

WEST VIRGINIA. Diesel Plant Generates Power for Price Hill, J. H. Edwards. *Coal Age*, vol. 35, no. 11, Nov. 1930, pp. 654 and 664, 5 figs. on 654. Largest Diesel installation in United States erected to furnish power exclusively for coal mining, in Raleigh County, W. Va.; four 360-hp. vertical engines, each direct-connected to 300-kva. 2400-volt generator, all in building 40 by 60 ft.

Electric Drive

CARGO HANDLING. Alternating Current Gaining for Materials Handling Drives, J. W. Speer. *Matls. Handling and Distribution*, vol. 5, no. 4, Jan. 1931, pp. 53-54, 3 figs. Disadvantages of induction motor; application of a.c. types especially to ore-handling equipment.

IRON AND STEEL PLANTS. Electrical Developments in the Iron and Steel Industry for 1930, D. W. Dean. *Rolling Mill Jl.*, vol. 4, no. 12, Dec. 1930, pp. 651-656, 5 figs. Discussion of extensive application of electrical equipment to rolling-mill drives, their auxiliaries and related steel-mill equipment; total horsepower applied to main drive motors for year ending December 1, 1930 was 151,540 as compared with 139,350 for preceding year.

Electric Equipment

DESIGN. Electric Field Records Notable Progress. *Power*, vol. 73, no. 1, Jan. 6, 1931, pp. 27-29, 5 figs. Turbine-driven 200,000-kva. generators to operate at 1800 r. p. m.; first hydrogen-cooled generator goes into operation; field for outdoor type of machines widened; mercury-arc rectifier applications increase rapidly new system of motor control.

FLASHOVER. The Influence of Altitude Upon the Flashover and Sparkover Characteristics of Electrical Equipment, S. Whitehead and W. D. Owen. *World Power* (*Lond.*), vol. 14, no. 83, Nov. 1930, pp. 404-414, 21 figs. partly on supp. plates. General nature of dependence of sparkover voltages upon air density; general principles, together with formulas for simple cases; it is shown that, for small changes, discharge voltage is roughly proportional to air density; effect of altitude on air density; different theoretical treatments are discussed and formulas for effect developed; these are criticized, and most appropriate methods of attacking problem are indicated.

SELF-SYNCHRONIZING. The Versatility of Application of Selsyn Equipment, R. A. Corby. *Gen. Elec. Rev.*, vol. 33, no. 12, Dec. 1930, pp. 706-711, 13 figs. Typical installations of indicators and control devices list showing some of uses to which Selsyn apparatus has been adapted with decided advantage; as remove control devices and as remote indicators.

TESTING. The Testing of Protective Gear, W. Wilson. *World Power*, vol. 15, no. 85, Jan. 1931, pp. 17-22, 9 figs. Principles and methods that are made use of in various testing operations to which apparatus is subjected.

Elevators

CONTROL. Electric Levelling Gear for Lifts. *Engineering* (*Lond.*), vol. 130, no. 3387, Dec. 12, 1930, pp. 742-743, 6 figs. Arrangement devised and patented by M. D. Scott, of Marryat and Scott, London, known as Levelectric, employs two motors, smaller being mounted above larger to economize floor space.

ELECTRIC. Higher Car Speeds Proposed for Elevators. *Power*, vol. 73, no. 1, Jan. 6. 1931, pp. 30-31, 2 figs. Developments nearing accomplishment are car speeds of 1200 ft. per min., double-deck cars serving two floors at a time and local and express cars in same hoistway.

Modern Lifts, L. S. Atkinson. *Elec. Times*, vol. 79, no. 2045, Jan. 1, 1931, pp. 5-8, 3 figs. Recent developments and latest types in use.

Electric Lines

AERIAL SURVEYING. Aerial Survey for Transmission Line Location, F. G. Dana. *Civil Eng.* (*N. Y.*), vol. 1, no. 4, Jan. 1931, pp. 249-252, 7 figs. Aerial methods adopted on Bagnell transmission-line location; use of stereoscope for binocular study of overlapping photographs; standard flying equipment used; ground field work; comparison of costs of aerial surveys with direct contact prints and with enlarged prints and ground controls.

PROTECTION. Selective Protection of Two Parallel Feeders with Small Resistance, L. A. Lentin. *Electritchestvo*, no. 20, Oct. 1930, pp. 804-807, 5 figs. Problem of selective protection of two parallel feeders fed on both sides by parallel working power stations is analyzed.

Engineering

HUMAN ASPECTS. Engineering Encounters Human Nature, E. D. Smith. *Mech. Eng.*, vol. 53, no. 1, Jan. 1931, pp. 1-4. Engineer, in launching new technological processes in old world, is not merely putting new wine into old bottles; he is putting high voltage into old wiring; it is important part of task of engineering to see that wiring is made adequate to new load; social responsibility incurred by engineer; effect of introduction of automatic loom in two cases; when technological developments pass from ideas to realities, engineering encounters human nature; engineer's responsibility for adapting mechanism to man.

Furnaces

ENAMELING. Welded Furnaces Meet all Requirements. *Welding Engr.*, vol. 15, no.12, Dec. 1930, pp. 33-36, 12 figs. Application of welding in electric furnaces and conveyors of vitreous-enameling plant of Edison General Electric Appliance Co., manufacturers of "hotpoint" electric appliances, Chicago, Ill.; data on operation and temperatures.

HEAT TREATING. The Use of Electricity in the Heat Treatment and Welding of Metals, A. N. Otis and W. L. Warner. *Mill and Factory Illustrated*, vol. 5, no. 1, Jan. 1930, pp. 48-50, and 92, 9 figs. Features of electrically-heated water-sealed furnaces of Kenworthy type widely used for bright annealing copper wire and similar products.

HIGH FREQUENCY. High Frequency Induction Heating, H. Smethurst, Jr. *Instn. Engrs.—Jl.*, vol. 41, part 3, Dec. 1930, pp. 113-130, 9 figs. History of development; comparison of types.

INDUCTION. Tonnage Melting by Coreless Induction, E. F. Northrup. *Iron Age*, vol. 127, no. 3, Jan. 15, 1931, pp. 228-233, 7 figs. Operating principles and application of high-frequency induction furnaces including data on power requirements, size of furnaces and refractory materials.

Fuses

TESTING. The Detection of Transient Arcs in Metal-Clad Fusible Cutouts, P. D. Morgan and H. W. Baxter. *Instn. Elec. Engrs. —Jl.* (*Lond.*), vol. 69, no. 408, Dec. 1930, pp. 95-99, 8 figs. Directions for employment of neon lamp as substitute for oscillograph in detection of transient low-current arcs between case and poles of metal-clad fusible cut-outs operating under short-circuit conditions. Bibliography.

Generators

DESIGN. Impulse-Short Circuit Generators (Stosskurzschlussgeneratoren), F. Niethammer. *Elektrotechnik und Maschinenbau* (*Vienna*), vol. 48, no. 49, Dec. 7, 1930, pp. 1077-1083. For practical testing of high capacity electric circuit breakers with actual short-circuit capacities, so-called impulse short circuit generators are used in test stands; fundamentals of design of such generator are given.

Increase in Use of Single Element Generators Shown by Survey. *Power Plant Eng.*, vol. 34, no. 24, Dec. 15, 1930, pp. 1418-1422, 2 figs. Study of generating equipment installed in principal power plants of country indicates tendency toward use of large single-element generators rather than double or triple-shaft design inaugurated several years ago; largest single-element machine in use is 160,000 kva. machine in East River station; table illustrating electric-generator practise in 25 power plants.

EXCITATION. Excitation of Generators (Bektachtiging van Generatoren), M. van der Veen. *Polytechnisch Weekblad* (*Amsterdam*), vol. 24, no. 50, Dec. 11, 1930, pp. 851-853, 6 figs. Mathematical analysis by which attempt is made to show along theoretical lines that assumption that magnetizing characteristic of automatically regulated generator should be linear saturation curve, must be incorrect.

SYNCHRONOUS. Permissible Errors in Synchronizing Generators, H. S. Baker. *Elec. News*, vol. 40, no. 1, Jan. 1, 1931, pp. 35-36. Analysis of two common errors, i. e. number of electrical degrees of phase difference between generator and bus at instant of breaker closure; and difference in speeds of generator and bus.

WATERWHEEL. Niagara's Latest Unit. *Elec. News* (*Toronto*), vol. 39, no. 24, Dec. 15, 1930, pp. 65-66, 2 figs. Power plant was finally completed with installation of tenth 58,000 hp. waterwheel-driven generator at Queenston generating station of Hydroelectric Power Commission of Ontario; unit has generator rating of 55,000 kv.a., 12 kv., 80 per cent p. f., 25-cycle, 187.5 r. p. m., while hydraulic turbine is rated at 58,000 hp. at 294 ft. head; total installed generator capacity of this station is now 497,000 kv.a.; enclosed air cooling is applied.

Illumination

INTERNATIONAL CONGRESS. International Illumination Congress, 1931. *Engineer* (*Lond.*), vol. 150, no. 3909, Dec. 12, 1930, p. 646. Congress being arranged by National Illumination Committee of Great Britain, in cooperation with Illuminating Engineering Society; will be held under auspices of International Commission on Illumination, and will take place during September of 1931.

Insulating Materials

PAPER. Paper in the Electrical Industry, W. H. Anderson. *Paper Mill*, vol. 7, no. 52, Dec. 27, 1930, pp. 11-12, and 14. Uses and application of paper in manufacturing electric equipment discussed under headings: condenser paper, wire wrapping paper, paper for laminated phenotic products, mica wrappers, condenser brushing paper, pressboard or fullerboard. Paper presented before Tech. Assn. Pulp and Paper Industry, Dec. 9, 1930.

TEXTILES. Treated Fabrics, A. R. Dunton and A. W. Muir. *Elecn.* (*Lond.*), vol. 105, no. 2741, Dec. 12, 1930, pp. 744-747, 8 figs. Notes on their use for insulating purposes; varnished fabrics and tapes.

Insulators

DESIGN. Designing Insulators to Combat Fog, S. M. Jones. *Elec. World*, vol. 96, no. 25, Dec. 20, 1930, pp. 1139-1142, 6 figs. Deposits are primary cause and fog itself only secondary cause of breakdown; surface leakage resistance is real criterion of performance; suspension string length factor; computing surface leakage resistance; adapting pin design to suspension use.

Lamps

LIFE. Life of Vacuum and Gas Filled Wendel Lamps and Causes of their Burning Out (Ueber die Lebensdauer der luftleeren und gasgefuellten Wendellampen und die Ursachen ihres Durchbrennens), F. Koref and H. O. Plaut. *Zeit. fuer Technische Physik* (*Berlin*), vol. 11, no. 12, 1930, pp. 515-521, 1 fig. Energy consumption are calculated and relation of these to life of lamps are analyzed.

NEON. Neon Lamps (Sulle lampade neon), N. Carrara. *Nuovo Cimento* (*Rome*), vol. 7, no. 8, Aug.-Sept.-Oct. 1930, pp. 318-325, 10 figs. partly on supp. plate. Experimental study of photoelectric sensitiveness of commercial neon lamps manufactured by Philips, Osram etc.

Lighting

AIRPORT. The Application of Illuminating Engineering Principals to Landing Field Floodlighting, L. C. Simpson. *Airports*, vol. 6, no. 1, Jan. 1931, pp. 12-13 and 30, 8 figs. Fundamental considerations of satisfactory landing field floodlighting are illustrated by sketches.

New Styles in Lights, H. C. Ritchie. *West. Flying*, vol. 8, no. 6, Dec. 1930, pp. 59-61, 5 figs. Use and operation of various types of lighting equipment, including beacon, floodlights, boundary lights, etc.; data on power consumption and locating.

MACHINE SHOPS. Lighting the Machine Shop, M. Warren. *Modern Machine Shop*, vol. 3, no. 7, Dec. 1930, pp. 11-14, 16, 18 and 48, 7 figs. Investigation of plants of various companies show effect of proper lighting on efficiency; graph illustrates relation between voltage and light intensity.

Loud Speakers

PROGRAM SERVICE. Latest in Amplifiers and Loudspeakers, W H. Hutter. *Telephony*, vol. 99, no. 25, Dec. 20, 1930, pp. 20-22. New developments in program service amplifiers and loudspeakers; origin of amplifiers and evolution with radio sets. Address read before U. S. Independent Telephone Assn.

Measuring Instruments

ELECTRIC. Switchboard Instruments. *Power Plant Eng.*, vol. 35, no. 1, Jan. 1, 1931, pp. 39-40. Instruments for measurement of voltage, current, power, etc.; instruments for various types of panels; alternating current generator circuits.

Motors

PROTECTION. Modern Methods of Enclosing Electric Motors, P. W. Arnold. *Mill and Factory Industrial*, vol. 8, no. 1, Jan. 1931, pp. 53-55, 13 figs. Problem which arise in protecting motors; most common enclosures; recent developments in enclosing motors.

Built-In Motor Protection, G. R. Anderson. *Indus. Eng.*, vol. 88, no. 12, Dec. 1930, pp. 605-607, 4 figs. Providing protection for inclosed ventilated types. (Continuation of serial.)

RAILROAD. Improvements on Street Car Motors and their Suspension (Perfectionnements apportes aux Moteurs de Tramways et à leur suspension), Castaing. *Industrie des Voies Ferrees et des Transports Automobiles* (*Paris*), vol. 24, no. 287, Nov. 1930, pp. 310-342, 28 figs. Notes with respect to current; supply voltage; operating conditions, modern developments as to magnetic and electric characteristics, mechanical improvements and systems of installation.

SPEED REGULATION. The Rossman System of Speed Control for Alternating-Current Motors. *Engineering* (*Lond.*), vol. 130, no. 3385, Nov. 28, 1930, pp. 694-695, 7 figs. Method is being used in number of American power stations, more particularly for driving forced-draft and induced-draft fans, though it is also applicable to feed pumps and other variable-speed equipment; driving unit consists of constant-speed a.c. motor of either synchronous or induction types, and variable-speed shunt-wound d.c. motor of much smaller output.

Networks

CALCULATION BOARDS. Representation of Generators on an A. C. Calculating Board, W. W. Parker. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 718-719, 4 figs. Means for representing synchronous machines; three-phase generator can be represented by single-phase proportional to actual phase-to-neutral terminal or internal voltage; schematic diagram of regulator and phase shifter arrangement for producing power for a.c. calculating board; equipment is described.

INTERCONNECTED. Synchronism Automatically Checked by Substations of Alabama Power Company, E. B. Henry and W. B. Morton. *South. Power Jl.*, vol. 48, no. 12, Dec. 1930, pp. 63-65, 3 figs. Function of synchronism check scheme is to check synchronism between two or more sources of power that are normally in continuous state of synchronism due to interconnection at another station; six synchronism check schemes now in automatic operation; system installed at Montgomery primary substations; operation under normal set-up; protective features.

LIGHTNING. Development of Electric Distribution Networks and Lightning Hazards (Le développement des réseaux de distribution d'énergie électrique et les dangers de la foudre), A. Boutaric. *Revue Gênêrale de l' Electricitê* (*Paris*), vol. 28, no. 22, Nov. 1930, pp. 865-872, 2 figs. Possible influence of overhead network systems on bringing about of electric lightning storms and danger of lightning for individuals and objects near line is analysed.

OVERVOLTAGES. Investigation by Means of Cathode Ray Oscillograph of Excess Voltages caused by Short-Circuit in 8 kilo-volt Distribution Network (Untersuchungen mittels Kathodenstrahl-Oszillograph der durch Erdschluss hervorgerufenen Ueberspannungen in einem 8 k V-Verteilnetz), K. Berger. *Schweiz. Elektrotechnischer Verein* (*Assn. Suisse des Electriciens*)—*Bul.* (*Zurich*), vol. 21, no. 23, Dec. 7, 1930, pp. 756-788, 47 figs. Magnitude and development of excess voltage dependent on location of short circuit; action of obsolete protective equipment and behavior of induction regulator and current transformers are analyzed; deductions are made with respect to insulators.

PLANNING. A Master Plan for Sound Growth in System Expansion. *Elec. News*, vol. 40, no. 1, Jan. 1, 1931, pp. 31-32 and 34. Through coordination and planning it is possible for modern light and power system to get most effective and economical use of money, men and equipment needed; it is possible to operate and build utility in terms of economic facts and business principles whereby waste is eliminated and maximum values are had from current investments.

Oscillographs

CATHODE-RAY. The Position of Cathode Ray Instruments in the Field of Oscillography, O. Ackerman. *Instruments*, vol. 3, no. 12, Dec. 1930, pp. 775-777. Proper field of cathode-ray instruments starts where limitations of moving-coil instruments are reached, i. e., in recording of frequency phenomena over 5000 cycles per sec.; in study of single phenomena (occurring at random) where phenomenon itself must start process of recording with less than 1/50th of sec.; in measuring voltages with negligible loss of power (electrostatic methods); in direct recording of relations where abscissa is electrical quantity; in cases where good visibility of registrations of instrument is required.

Phase Advancers

The Theory and Performance of Phase Advancers, J. J. Rudra and M. Walker. *Instn. Elec. Engrs.—Advance Paper*, 1930, 25 pp., 37 figs. Paper divides advancers into "expedor" advancers in which voltage is proportional to secondary current, and "susceptor" advancers in which it is proportional to secondary voltage; complete theory of expedor advancer is worked out from equivalent circuit, and test results are compared with what might be expected from theory; comparison of advancers of different phase angles under different conditions is made to determine which is best for given purpose; equivalent circuit of susceptor advancer is given and from it complete theory is worked out.

Piezoelectric Quartz

Summary of Piezo-Electric Crystal Conference Held by U. S. Navy Department, December 3-4, 1929. *Inst. Radio Engrs.—Proc.*, vol. 18, no. 12, Dec. 1930, pp. 2128-2135, 3 figs. For purpose of bringing about uniform understanding among conferees, representatives of Naval Research Laboratory offered for discussion; resumé of crystallography and piezoelectricity of quartz; description of methods of cutting and testing quartz used at Naval Research Laboratory; account of experience and practices of laboratory relative to two principal "cuts" used in art.

Power Industry

Congress of the International Association of Producers and Distributors of Electric Power in Brussels, September 1930 (Congrês de Bruxelles de l'Union internationale des Producteurs et Distributeurs d'Energie électrique (Septembre 1930). *Revue Gênêrale de Electricitê* (*Paris*), vol. 28, no. 23, Dec. 6, 1930, pp. 885-894. Grounding of neutral in high and low tension networks; parallel operation of generating stations; joint operation of high tension lines and telephone communication lines.

EMPLOYEES TRAINING. Possible Executives in the Making, J. R. Martin. *Elec. Light and Power*, vol. 8, no. 12, Dec. 1930, pp. 40-43, 1 fig. President's Training Course in Management as originated by Britton I. Budd, president of Public Service Co. of Northern Illinois, is described; company operates in territory approximating 6000 sq. mi. surrounding Chicago, and serves some 318 communities, principally with electricity and gas; approximately 5000 men and women are employed; reasons for selecting number of employes to participate in course in management, and principles and policies governing its administration are set forth.

Power Supply

RURAL. Farm-Service—What of the Future, K. R. Mackinnon. *Elec. World*, vol. 95, Mar. 29, 1930, pp. 657-660, 2 figs. Central-station industry has not evolved coherent and workable policy of national scope for farm service extensions; author cites practices and policies of Nebraska Power company but not necessarily because these are thought to be answer to national problem.

Radio

AERIAL TRANSPORTATION. Wireless Direction Finding, C. B. Carr. *Aircraft Eng.* (*Lond.*), vol. 2, no. 22, Dec. 1930, pp. 305-307. Relative merits of various directional-transmission and reception systems for purpose of assisting air operating company in selection of proper equipment; principles of equi-signal and rotating beacon; Marconi-Bellini-Tosi system; Marconi-Adcock system; Marconi-Robinson system.

The Development of Visual Type of Radio Range Transmitter Having A Universal Application to the Airways, W. E. Jackson and S. L. Bailey. *Inst. Radio Engrs.—Proc.*, vol. 18, no. 12, Dec. 1930, pp. 2059-2101, 35 figs. Visual type of radio range which has universal application to civil airways of United States; relative merits of aural and visual systems of course indication, theory of production of 12 courses by utilizing three-phase radio-frequency source is presented; general description of transmitter; necessary requisites of goniometer design; performance curves of final goniometer illustrate effect of these factors on results.

Aircraft Radio Telephone Successful, R. Johnson. *Telephony*, vol. 99, no. 26, Dec. 27, 1930, pp. 31-32, 2 figs. Demonstration by Air Transport Co. proves that plane-ground voice communications are not only practicable, but successful; discussion of other developments in air transport communication in 1930.

AIRPLANES. System of Guiding Airplanes (Sur un procédé de guidage des avions), Biolt. *Onde Electrique* (*Paris*), vol. 9, no. 103, Nov. 1930, pp. 520-526, 1 fig. System allows for exact location of plane when traveled traject is known; to this end interference zone is created between 2 synchronous emissions and meter installed on receiver of airplane which records number of successive maxima and minima; from this, course traveled is deduced.

AMPLIFIERS. An Amplifier for Measuring Small Currents, R. D. Bennett. *Rev. Sci. Instruments*, vol. 1, no. 8, Aug. 1930, pp. 466-470, 5 figs. Amplifier is described which uses four-electrode tube of ordinary type, and gives maximum current sensitivities of order of 10 to 18 type, and gives maximum current sensitivities of order of 10 to minus 18 power amperes; novel feature consists in using as grid leak positive ion emission of filament.

DESIGN. Effect of Output Load upon Frequency Distortion in Resistance Amplifiers, H. A. Thomas. *Experimental Wireless*, vol. 8, no. 88, Jan. 1931, pp. 11-17, 11 figs. Simple mathematical analysis pertaining to loud-speaker load, input impedance of power-tubes stage, anode circuit impedance of stage 2, amplification of stage 2, input impedance of stage 2, anode circuit impedance of stage 1, amplification of stage 1, overall amplification; experimental results; results obtained; case of 3 stages of low amplification factor tubes; amplification curves.

CONDENSERS. A Variable-Capacitance Cylindrical Condenser for Precision Measurements, and a Wavemeter for Short Wavelengths, E. B. Moullin. *Instn. Elec. Engrs.—Advance Paper received* Nov. 13, 1930, 12 pp., 19 figs. Cylindrical condenser which has been developed for precision measurements at very high radio frequencies; one cylinder is always totally enclosed by other and capacitance is varied by altering distance between axes of cylinders; paper also includes tentative design for short range short wave absorption wavemeter in which same principles of construction are used.

FREQUENCY MEASUREMENT. A New Method of Measurement of Resistance and Reactance at Radio Frequencies, F. M. Colebrook and R. M. Wilmotte. *Instn. Elec. Engrs.—Advance Paper received* Nov. 29, 1930, 10 pp., 9 figs. Method of measuring radio frequency resistance of coils is described; it depends on change in reactance of tube controlled oscillating circuit when it is coupled to circuit under investigation, and does not require any measurement of current or voltage; practical details of working of method and construction of necessary apparatus are given.

GENERATORS. Power Equipment for Aircraft Radio Transmitters, J. D. Miner. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 1, Jan. 1931, pp. 59-77. Systems of power equipment now used or contemplated for supplying power to aircraft radio transmitters; various types of power equipment are described and advantages and disadvantages of each type are discussed.

Power for Aircraft Radio, F. C. Doughman. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 701-704, 10 figs. Generators used to supply power for aircraft radio can be driven in wide variety of ways, depending upon size of plane, service for which it is designed, and amount of power required; alternator of inductor type can be combined with d.c. motor to make highly efficient battery driven aircraft unit; oldest and best known type of aircraft power equipment is storage battery driven d.c. dynamotor; constant-speed propeller has made possible use of wind-driven alternator; equipment is illustrated.

Railroads

ELECTRIC. The Contribution of Modern Electrical Equipment to Transportation. H. L. Andrews. *N. Y. Railroad Club—Proc.*, vol. 41, no. 1, Nov. 1930, pp. 9369-9399, 26 figs. and charts. Savings due to electric equipment for street-car lines, trolley buses, gas-electric buses, and electrified steam-railroad transportation systems.

SIGNALS AND SIGNALING. Pennsylvania Installs Centralized Control on 30.3 Miles of Single Track. *Ry. Signaling*, vol. 23, no. 12, Dec. 1930, pp. 434-436, 4 figs. Pennsylvania has completed installation of centralized traffic control between Ben Davis, Ind., and Almeda, which is portion of main line between Indianapolis, Ind., and St. Louis, Mo.; characteristics of line and traffic; 12 min. saved on each freight train stop; second tracking deferred; first installation of Union three-wire coded system.

Remotely-Controlled Interlocking Reduces Operating Costs, R. L. Davis. *Ry. Signaling*, vol. 23, no. 12, Dec. 1930, pp. 429-430, and 433, 4 figs. Michigan Central replaces mechanical plant at crossing of Michigan Central and Grand Trunk Western at Rochester Jct., Mich.; annual saving of $5000 in operating expenses.

Rectifiers

HARMONICS. The Calculation of Harmonics in Rectified Currents, E. L. E. Wheatcroft. *Instn. Elec. Engrs.—Jl.* (*Lond.*), vol. 69, no. 408, Dec. 1930, pp. 106-108, 9 figs. New mathematical method is proposed which treats rectifier characteristic as continuous curve; method of reducing equations to tractable form for solution by successive approximations, using algebra of plane vectors; it is shown by means of numerical example how approximations converge on true value deduced by classical method.

MERCURY ARC. Mercury Arc Rectifier Equipment for the Melbourne Tramways. *Engineer (Lond.)*, vol. 150, no. 3909, Dec. 12, 1930, pp. 655-656, 5 figs. Largest equipment sent to Australia for Melbourno street railroad has capacity of 500 kw., and is designed to operate on 6600-volt, three-phase system and to feed into 600-volt d.c. two-wire system, plant being arranged for fully automatic control; sub-station is brought into operation by means of voltage relay and/or time switch, and is shut down by means of low-current relay or time switch.

Relays

A Thermal Overload Relay, A. E. Capon. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 708-709, 4 figs. Relay differs from other thermally operated relays in that heat storage is contained within heater element itself, without any external heat-storing agency; characteristic was obtained by using heater coil of comparatively large mass; to provide protection against instantaneous overload, additional tripping device is connected in series with heating element; operating characteristics with various stationary contact settings, is given in curves.

Resonance

ELECTRIC CIRCUITS. Theory of Two Coupled Oscillatory Circuits (Zur Theorie zwier gekoppelter Schwingungskreise, I), V. Petrzilka. *Elektrische Nachrichten-Technik (Berlin)*, vol. 7, no. 8, Aug. 1930, pp. 317-324, 6 figs. Method of calculation of resonance curves of two circuits from energy supplied to them.

Switchboards

REMOTE CONTROL. Miniature Remote Control Switchboards, L. J. Cissna. *Elec. Jl.*, vol. 27, no. 12, Dec. 1930, pp. 689-695, and 717, 12 figs. Miniature remote-control switchboards represent one of latest developments in switchgear apparatus; development; mounting of control equipment; auxiliary relays; remote metering; wiring; power supply; circuits and their operation; substation equipment; advantages.

STEEL. Development of the Modern Steel Switchboard, E. G. Bern and F. E. Jaquay. *Elec. Light and Power*, vol. 8, no. 12, Dec. 1930, pp. 54, 56 and 58, 7 figs. Development and comparison between older and modern equipment; various examples of modern steel switchboards are illustrated.

Switchgear

METAL CLAD. Metal-Clad Switchgear, R. O. Waltham. *Elec. Light and Power*, vol. 9, no. 1, Jan. 1931, pp. 35-37, 7 figs. Before any manufacturer in United States was ready to supply this type of apparatus, Public Service Co. imported complete distribution substation installation of Reyrolle 4-kv. metal-clad gear and placed equipment in service at Bellwood substation in 1926; experience resulted in development of number of features to adapt gear to American operating conditions which were incorporated in gear subsequently manufactured by Allis-Chalmers Co. under Reyrolle patents.

Telephone

RELAYS. Economics of the Application of Relays to Telephone Circuits, W. W. Wells. *Bell Laboratories Rec.*, vol. 9, no. 5, Jan. 1931, pp. 224-228, 4 figs. To design ideal relay for each particular condition would frequently require design of different relay for each application, and would ultimately result in manufacture of excessive number of types; development of new relay structures, therefore, is not frequently advisable; economic application of existing relay structures; development of new windings and spring arrangements as required.

Trackless Trolleys

MAINTENANCE AND REPAIR. Trolley Buses Cost Less to Maintain than Petrol Buses, C. O. Silvers. *Bus and Coach*, vol. 3, no. 25, Jan. 1931, pp. 3-6, 5 figs. Merits of trackless trolleys as compared to motor bus; tables give data on costs per 100 seat miles; vehicle maintenance and repairs; cost of power and its distribution.

Transformers

CONNECTION. Systems of Transformer Connection. *Power Plant Eng.*, vol. 35, no. 1, Jan. 1, 1931, pp. 44-46, 38 figs. Internal and external connections for various voltage and current combinations.

CONSTRUCTION. Recent Progress in Construction of Transformers of Great Power and Very High Voltage etc. (Recenti progressi nella costruzione dei trasformatori di grande potenza ed altissima tensione considerazioni generali d'impiego), B. Cerretelli. *Elettrotecnica (Milan)*, vol. 17, nos. 28 and 29, Oct. 5, 1930, pp. 638-646, and Oct. 15, pp. 661-672, 54 figs. General review of progress in design of construction, including theoretical analysis of operation of very large transformers, with special reference to transformers of Cardano and Cislago stations, in northern Italy, of 25,000 to 36,000 kva. and 220,000 volts; also description of 1,050,000-volt transformers built for Societa Pirelli.

MAINTENANCE AND REPAIR. Periodic Care of Transformers Cuts Maintenance Costs, A. A. Fredericks. *Power*, vol. 71, no. 9, Mar. 4, 1930, pp. 354-357, 5 figs. Faults that may develop in transformers and how to remedy them.

MANUFACTURE. Fundamentals of Transformer Construction. *Power Plant Eng.*, vol. 35, no. 1, Jan. 1, 1931, pp. 42-44, 6 figs. Types of cores and windings, leads, casings, methods of mounting and cooling; pole type substation for small industrial installations.

TRANSIENTS. Transient Currents in Transformers, H. M. Turner. *Franklin Inst.—Jl.*, vil. 211, no. 1, Jan. 1931, pp. 1-36, 31 figs. Principles underlying phenomena of transient currents in transformers, when connected to source of power, by starting with simple inductive circuits in permanent state and gradually leading up to more involved case of transformer in transient state; elements affecting transient current are considered individually; appendix describes transient visualizer and oscillograph assembly.

Transmission Lines

GROUND WIRE. The Neglected Ground Wire (Den miskjente jordline), W. R. Blumer. *Elektroteknisk Tidsskrift (Oslo)*, vol. 43, no. 32, Nov. 15, 1930, pp. 439-444, 8 figs. Importance of equipping towers for electric high-tension lines with ground wires as protection against lightning; several instances reviewed where lack of adequate grounding caused severe damage to towers; constructions of towers of wood and steel used in Germany and Sweden.

LIGHTNING. Lightning Research in the Field and Laboratory, E. Beck. *Elec. Light and Power*, vol. 9, no. 1, Jan. 1931, pp 59, 62 and 64, 10 figs. Investigative program was carried out during summer of 1930; lightning records were made with automatic cathode ray oscillograph of Norinder type which is automatic within itself and begins to register instant that applied surge voltage exceeds normal line voltage; oscillograms of typical waves measured.

MAINTENANCE AND REPAIR. Live Line Tools for High Voltage Maintenance, W. Smith. *Elec. Light and Power*, vol. 8, no. 12, Dec. 1930, pp. 45-46, 48 and 50, 9 figs. New method of making repairs to high voltage lines was introduced a few years ago which is rapidly coming into general use, making it possible to repair, or even rebuild completely, high voltage lines without taking them out of service; this is done by use of so-called "live line tools," with them, work can be done during regular hours, time required being but slightly greater than with line dead; equipment and its application is described. Paper read before Northwest Elec. Light and Power Assn.

PROTECTION. Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 1, Jan. 1931, pp. 48-51, 12 figs. Impedance relay is dependent for its operation on both excess current and low voltage; this feature is secured by addition of voltage restraining coil to ordinary over-current relay element; transmission lines operated in parallel can best be protected by use of selective differential current relay; selective-differential relay. (Continuation of serial.)

RELAYS. Interstation Control Wires Avoid Cascade Relaying, G. M. Babcock. *Elec. World*, vol. 95, Mar. 29, 1930, p. 646, 1 fig. Cascade relaying in transmission-line system causes longest time delay at main switching station, where short-circuit current is greatest and should be cleared quickly to avoid serious disturbance on entire system; ideal relaying scheme is one which will work instantaneously with short circuit on line with which it is identified, but remain inoperative with short circuit on any other part of system; Los Angeles Gas & Electric Corporation has operation relay scheme of this character.

WIND PRESSURE. Measurement of the Wind Pressures on Overhead Lines, R. H. Sherlock. *Nat. Elec. Light Assn.—Bul.*, vol. 18, no. 1, Jan. 1931, pp. 29-34, 11 figs. Methods used to carry on experimental study of strength and loading of pole lines, and brief description of instruments which were developed for study of wind gusts; representative data arranged in form adopted for summarizing and interpreting results; no conclusions are presented.

Vacuum Tubes

AMPLIFICATION. Reduction of Distortion and Cross-Talk in Radio Receivers by Means of Variable-Mu Tetrodes, S. Ballantine and H. A. Snow. *Inst. Radio Engrs.—Proc.*, vol. 18, no. 12, Dec. 1930, pp. 2102-2127, 18 figs. In attempting to control audio output of radio receiver employing present types of tubes by varying control grid bias or screen-grid voltage distortion, due to non-linearity of output-input voltage relation for tube, and cross-talk are encountered at higher signal voltages; two shielded tetrode tubes, designated as types 550 and 551, have been developed to reduce these effects.

APPLICATIONS. Industrial Uses of Electron Tubes, W. R. G. Baker, A. S. Fitzgerald and C. F. Whitney. *Electronics*, vol..2, no. 1, Jan. 1931, pp. 467-469, 8 figs. Principal objects which are aimed at in applying electron tubes to power control problems; circuits; notes on features of electron tubes; phase relation control; vacuum-tube control of thyratron; thyratron tuned relay; thyratron flasher; methods of controlling output; a.c. output.

Welding

ARC. Facts Concerning A. C. and D. C. Welding, J. C. Holslag. *Welding*, vol. 1, no. 14, Dec. 1930, pp. 992-993. Favorable and unfavorable characteristics of both processes; a.c. machine is 70 to 90 per cent efficient when considered as piece of electrical apparatus, whereas motor generators and resistance apparatus vary from 50 per cent efficiency electrically down to 5 per cent; first cost, installation and operation are all in favor of a.c. welding.

ATOMIC HYDROGEN. Welding with Atomic Hydrogen Process, S. Martin, Jr. *Welding*, vol. 1, no. 14, Dec. 1930 pp. 990-991, and 998, 6 figs. Proper method for welding steel castings, alloy steels, other metals and the repair of dies; pertinent notes on hydrogen.

AUTOMOBILE. Unusual Welding Jobs in Ford Fabrication. *Am. Mach.*, vol. 73, no. 15, Oct. 9, 1930, pp. 586-588, 5 figs. Method used in manufacture of blanks for differential ring gear, axles, radius rods, mufflers.

JOINTS. How Strong are Welded Joints in Tubular Members of Airplanes, H. L. Whittemore and W. C. Brueggeman. *Iron Age*, vol. 126, no. 26, Dec. 25, 1930, pp. 1925-1926. Paper previously indexed from Am. Welding Soc.—Jl., Sept. 1930.

LOCOMOTIVE BOILERS. Welding Practice on the Illinois Central System. *Boiler Maker*, vol. 30, no. 12, Dec. 1930, pp. 330-335, 7 figs. Rules developed by Illinois Central for fusion welding of locomotive and stationary boilers; instructions for handling oyxgen and acetylene regulations.

MACHINERY. Economies in Welding Machine Parts, J. H. Babcock. *Welding Engr.*, vol. 15, no. 7, July 1930, p. 56, 12 figs. Welded chain guards, gears, wheels, levers and other parts show large savings in cost over riveted construction or castings.

MACHINES. Making Steel Axle Housings by Arc Welding, J. M. Robinson. *Machy. (N. Y.)*, vol. 37, no. 5, Jan. 1931, pp. 329-330, 8 figs. Method of Oakland Motor Car Co., in producing lightweight rear-axle housings by joining steel stampings on automatic arc-welding machine; data on time requirements, tolerances and properties of weld.

New Application of Arc Welding Machine in Street Railroad Practice (Eine Neuartige Verwendung der Lichtbogen-Schweissmaschine im Strassenbahnbetrieb), O. Kranner *Verkehrstechnik (Berlin)*, no. 33, Aug. 15, 1930, pp. 429-430, 2 figs. Possibility of application of arc welding machine for measuring of rail return joints, equipment of street railroads in Graz.

RESEARCH. Practise in Welding Turns to Research. J. R. Griffith. *Welding Engr.*, vol. 15, no. 12, Dec. 1930, pp 29-31, 1 fig. Effect of operator's skill on welds; investigation conducted at Oregon State College on eccentricity of angle connections; stress distribution of welded joint is little, if at all, better than for riveted joint. Paper presented before Int. Acetylene Assn., Chicago, Ill., Nov. 12-14, 1930.

STEEL BUILDINGS. Welding Applied to Two Buildings. *Eng. News Rec.*, vol. 105, no. 24, Dec. 11, 1930, pp. 925-928, 6 figs. Symposium consisting of two articles: Useful Structural Detail Developed for Large All-Welded Building, J. G. Ritter; Contract and Work Procedure on a 14-Story Field-Welded Building, W. F. Carson and F. P. McKibben; construction of 11-story central engineering laboratory building of Westinghouse Electric and Manufacturing Co.; method of erecting six sections of DuPont office building in Wilmington, Del.

Officers and Committees

Institute Officers 1930-1931

President

WILLIAM S. LEE

Junior Past Presidents

R. F. SCHUCHARDT
HAROLD B. SMITH

Vice-Presidents

HERBERT S. EVANS
W. S. RODMAN
C. E. FLEAGER
E. C. STONE
C. E SISSON
H. V. CARPENTER
G. C. SHAAD
I. E. MOULTROP
H. P. CHARLESWORTH
T. N. LACY

Directors

F. C. HANKER
E. B. MEYER
H. P. LIVERSIDGE
J. ALLEN JOHNSON
A. M. MACCUTCHEON
A. E. BETTIS
J. E. KEARNS
F. W. PEEK, JR.
C. E. STEPHENS
A. B. COOPER
A. E. KNOWLTON
R. H. TAPSCOTT

National Treasurer

W. I. SLICHTER

National Secretary

F. L. HUTCHINSON

General Counsel

PARKER & AARON
30 Broad Street, New York

Local Honorary Secretaries

T. J. Fleming, Call B. Mitre 519, Buenos Aires, Argentina, S. A.

H. W. Flashman, Aus. Westinghouse Elec. Co., Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.

F. M. Servos, Rio de Janiero Tramways, Light & Power Co., Rio de Janeiro, Brazil.

A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.

A. S. Garfield, 173 Boulevard Haussmann, Paris 8 E., France.

Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.

P. H. Powell, Canterbury College, Christchurch, New Zealand.

M. A. Chatelain, Polytechnical Institute, Apt. 27, Leningrad, Sosnowka 1/3, U. S. S. R.

Axel F. Enstrom, 24a Ingeniorsvetenskrapsakademien, Stockholm, 5 Sweden.

W. Eldson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

INSTITUTE COMMITTEES

(A list of the personnel of Institute committees may be found in the January issue of ELECTRICAL ENGINEERING)

General Standing Committees and Chairmen

Executive	W. S. Lee
Finance	C. E. Stephens
Meetings and Papers	A. E. Knowlton
Publication	W. S. Gorsuch
Coordination of Institute Activities	H. P. Charlesworth
Board of Examiners	H. W. Drake
Sections	Everett S. Lee
Student Branches	W. H. Timbie
Membership	J. Allen Johnson
Headquarters	R. H. Tapscott
Law	E. B. Meyer
Public Policy	Bancroft Gherardi
Standards	F. D. Newbury
Edison Medal	D. C. Jackson
Lamme Medal	Charles F. Scott
Code of Principles of Professional Conduct	F. B. Jewett
Award of Institute Prizes	A. E. Knowlton
Safety Codes	A. W. Berresford
Engineering Profession	H. A. Kidder
Columbia University Scholarships	W. I. Slichter
Popular Science Award	A. E. Knowlton
Advisory Committee to the Museum of Science and Industry in the City of New York	J. P. Jackson

Technical Committees and Chairmen

Automatic Stations	F. Zogbaum
Communication	G. A. Kositzky
Education	W. R. Work
Electrical Machinery	Philip L. Alger
Electric Welding	P. P. Alexander
Electrochemistry and Electrometallurgy	P. H. Brace
Electrophysics	O. E. Buckley
General Power Applications	C. W. Drake
Instruments and Measurements	E. J. Rutan
Applications to Iron and Steel Production	A. C. Cummins
Production and Application of Light	George S. Merrill
Applications to Marine Work	R. A. Beekman
Applications to Mining Work	Carl Lee
Power Generation	F. A. Allner
Power Transmission and Distribution	P. H. Chase
Protective Devices	Raymond Bailey
Research	L. W. Chubb
Transportation	Sidney Withington

INSTITUTE REPRESENTATIVES

(The Institute is represented on the following bodies; the names of the representatives may be found in the January issue of ELECTRICAL ENGINEERING)

Aeronautical Radio Research, Liaison Committee on
Alfred Noble Prize Committee, A. S. C. E.
American Association for the Advancement f Science, Council
American Bureau of Welding
American Committee on Electrolysis
American Engineering Council Assembly
American Marine Standards Committee
American Standards Association
American Year Book, Advisory Board
Charles A. Coffin Fellowship and Research Fund Committee
Committee of Apparatus Makers and Users, National Research Council
Committee on Elimination of Fatigue, Society of Industrial Engineers
Committee on Heat Transmission, National Research Council
The Engineering Foundation
Engineering Societies Monographs Committee
Hoover Medal Committee
John Fritz Medal Board of Award
Joint Committee on Welded Rail Joints
Joint Conference Committee of Four Founder Societies
Library Board, United Engineering Trustees, Inc.
National Fire Protection Association, Electrical Committee
National Fire Waste Council
National Research Council, Engineering Division
National Safety Council, Electrical Committee of A. S. S. E.—Engineering Section
Radio Advisory Committee, Bureau of Standards
United Engineering Trustees, Inc.
U. S. National Committee of the International Commission on Illumination
U. S. National Committee of the International Electrotechnical Commission
Washington Award, Commission of

GEOGRAPHICAL DISTRICT EXECUTIVE COMMITTEES

District	Chairman (Vice-President, A. I. E. E.)	Secretary (District Secretary)
No. 1—North Eastern	I. E. Moultrop, Edison Elec. Illum. Co., 39 Boylston St., Boston, Mass.	A. C. Stevens, General Electric Co., Schenectady, N. Y.
No. 2—Middle Eastern	E. C. Stone, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.	J. A. Cadwallader, Bell Tel. Co. of Pa., 416 Seventh Ave, Pittsburgh, Pa.
No. 3—New York City	H. P. Charlesworth, 463 West St., New York, N. Y.	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
No. 4—Southern	W. S. Rodman, Box 675, University, Va.	J. S. Miller, Jr., Box 12, University, Va.
No. 5—Great Lakes	T. N. Lacy, Mich. Bell Tel. Co., 1365 Cass Ave., Detroit, Mich.	A. G. Dewars, No. States Pr. Co., 15 S. 5th St., Minneapolis, Minn.

GEOGRAPHICAL DISTRICT EXECUTIVE COMMITTEES—*Continued*

District	Chairman (Vice-President, A. I. E. E.)	Secretary (District Secretary)
No. 6—North Central	Herbert S. Evans, University of Colorado, Boulder, Colo.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. C. Shaad, University of Kansas, Lawrence, Kans.	Robert W. Warner, University of Kansas, Lawrence, Kans.
No. 8—Pacific	C. E. Fleager, Pac. Tel. & Tel. Co., 140 New Montgomery St., San Francisco, Calif.	H. W. Hitchcock, 1050 Telephone Bldg., 740 South Olive St., Los Angeles, Calif.
No. 9—North West	H. V. Carpenter, State College of Washington, Pullman, Wash.	R. D. Sloan, State College of Washington, Pullman, Wash.
No. 10—Canada	C. E. Sisson, Canadian Gen. Elec. Co., 1025 Lansdowne Ave., Toronto, Ont.	W. L. Amos, Hydro-Elec. Pr. Com., 190 University Ave., Toronto, Ont.

Note: Each District Executive Committee includes the chairmen and secretaries of all Sections within the District and the chairman of the District Committee on Student Activities.

LOCAL SECTIONS OF THE INSTITUTE

Name	District	Chairman	Secretary	Secretary's Address
Akron	2	H. C. Paiste	Alvin P. Regal	Phila. Rubber Works Co., Akron, Ohio
Atlanta	4	H. O. Uhl	O. O. Rae	Westinghouse E. & M. Co., Atlanta, Ga.
Baltimore	2	W. B. Kouwenhoven	J. Wells	Western Elec. Co., 25 Broening Rd., Baltimore, Md.
Birmingham	4		O. E. Charlton	Allied Engineers, Inc., Birmingham, Ala.
Boston	1	J. P. Kobrock	G. J. Crowdes	Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
Chicago	5	F. H. Lane	L. R. Mapes	Ill. Bell Tel. Co., 212 W. Washington St., Chicago, Ill.
Cincinnati	2	T. C. Reed	L. L. Bosch	Columbia Eng. & Mgt. Corp., 314 West 4th St., Cincinnati, Ohio
Cleveland	2	F. W. Braund	John M. Smith	Nela Park, Cleveland, Ohio
Columbus	2	C. D. Price	K. Y. Tang	Ohio State University, Columbus, Ohio
Connecticut	1	Samuel Ferguson	R. G. Warner	Yale Univ., 10 Hillhouse Ave., New Haven, Conn.
Dallas	7	L. T. Blaisdell	G. A. Dyer	Southwestern Bell Tel. Co., Dallas, Texas
Denver	6	R. B. Bonney	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	LeRoy Braisted	J. J. Shoemaker	Detroit Edison Co., 2000-2nd Ave., Detroit, Mich.
Erie	2	G. R. McDonald	G. I. LeBaron	General Elec. Co., Erie, Pa.
Fort Wayn	5	W. J. Morrill	C. M. Summers	General Elec. Co., Fort Wayne, Ind.
Houston	7	C. D. Farman	Hezzie Clark	Humble Pipe Line Co., Drawer, 1761, Houston, Texas
Indianapolis-Laf.	5	E. G. Ralston	C. E. Dutton	15 W. New York St., Room 222, Indianapolis, Ind.
Iowa	5	J. K. McNeely	H. B. Hoffhaus	Des Moines El. Lt. Co., 312-6th Ave., Des Moines, Iowa
Ithaca	1	W. C. Ballard, Jr.	W. E. Meserve	614 E. Buffalo St., Ithaca, N. Y.
Kansas City	7	J. S. Palmer	Richard M. Ryan	510 Dwight Bldg., Kansas City, Mo.
Lehigh Valley	2	W. M. Harbaugh	J. H. Diefenderfer	Penn. Pr. & Lt. Co., Hazleton, Pa.
Los Angeles	8	H. W. Hitchcock	Philip S. Biegler	3551 University Ave., Los Angeles, Calif.
Louisville	4	James Clark, Jr.	Philip P. Ash	L. & N. R. R. Bldg., 9th and Broadway Ave., Louisville, Ky.
Lynn	1	A. L. Ellis	W. K. Dickinson	General Elec. Co., West Lynn Works, Lynn, Mass.
Madison	5	L. C. Larson	G. F. Tracy	Elec. Lab. Bldg., Univ. of Wisconsin, Madison, Wis.
Memphis	4	M. Eldredge	W. A. Gentry	Memphis Pr. & Lt. Co., Memphis, Tenn.
Mexico	3	B. E. Arias	L. Castro, Jr.	Departamento Electricidad y Telegrafos, Ferrocarriles Nacionales de Mexico, Mexico, D. F.
Milwaukee	5	F. A. Kartak	I. L. Illing	Milwaukee El. Ry & Lt. Co., 330 Pub. Serv. Bldg., Milwaukee, Wis.
Minnesota	5	D. K. Lewis	H. J. Pierce	Northwestern Bell Tel. Co., Minneapolis, Minn.
Nebraska	6	W. O. Jacobi	A. L. Turner	1112 Telephone Bldg., Omaha, Nebraska
New York	3	J B. Bassett	C. R Jones	Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
Niagara Frontier	1	E. S Bundy	G. W. Eighmy	General Elec. Co., 1100 Elec. Bldg., Buffalo, N. Y.
North Carolina	4	J. H. Paget	F. C. DeWeese	Carolina Pr. & Lt. Co., Raleigh, N. C.
Oklahoma City	7	F. J. Meyer	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	D. H. Kelly	J. L. MacBurney	El. St. Bat. Co., 1955 Hunting Park Ave., Phila., Pa.
Pittsburgh	2	C. T. Sinclair	F. A. Connor	General Elec. Co., 1309 Oliver Bldg., Pittsburgh, Pa.
Pittsfield	1	C. H. Kline	L. H. Burnham	General Electric Co., Pittsfield, Mass.
Portland, Ore.	9	A. H. Kreul	C. W. Fick	General Electric Co., Portland, Oregon
Providence	1	J. W. Young	O. W. Briden	Blackstone Valley G. & E. Co., 231 Main St., Pawtucket, R. I.
Rochester	1	Harvey J. Klumb	F. C. Young	Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
St. Louis	7	C. B. Fall	E. A. Forkner	Wagner Elec. Corp., 6400 Plymouth Ave., St. Louis, Mo.
San Antonio	7	D. W. Flowers	E. Bissett	San Antonio P. S. Co., 201 N. St., Mary St., San Antonio, Texas
San Francisco	8	P. B. Garrett	E. F. Maryatt	Pacific G. & E. Co., 245 Market St., San Francisco, Calif.
Saskatchewan	10	W. T. Hunt	A. B. Coward	Light and Power Dept., Regina, Sask., Canada
Schenectady	1	E. S. Henningsen	E. P. Nelson	D. C. Eng. Dept. General Elec. Co., Schenectady, N. Y.
Seattle	9	C. E. Carey	Philip D. Jennings	5560 Stuart Bldg., Seattle, Wash.
Sharon	2	S. S. Cook	R. M. Field	Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	4	J. H. Berry	Cecil Gray	Westinghouse E. & M. Co., 912 El. Bldg., Richmond, Va.
Spokane	9	Loren A. Traub	C. F. Norberg	Washington Water Pr. Co., Spokane, Wash.
Springfield, Mass	1	J. N. Alberti	L. C. Packer	Westinghouse E. & M. Co., Page Blvd., Springfield, Mass.
Syracuse	1	F. E. Verdin	Charles W. Henderson	504 University Pl., Syracuse, N. Y.
Toledo	2	F. H. Dubs	Max Neuber	1257 Fernwood Ave., Toledo, Ohio
Toronto	10	D. A. McKenzie	G. D. Floyd	Hydro El. Pr. Comm., 190 Univ. Ave., Toronto, Ont.
Urbana	5	C. E. Skroder	W. J. Putnam	123 Mat. Test. Lab. Univ. of Illinois, Urbana, Ill.
Utah	9	L. B. Fuller	Paul Ranson	Utah Apex Mining Co., Bingham Canyon, Utah
Vancouver	10	H. Vickers	C. Arnott	B. C. E. Ry. Co., Ltd., 425 Carrall St., Vancouver, B. C.
Washington	2	George W. Vinal	J. L. Carr	General Elec. Co., 800-15th St., N. W., Washington, D. C.
Worcester	1	J. K. Oldham	R. P. Bullen	General Elec. Co., Worcester, Mass.
Total 58				

STUDENT BRANCHES OF THE INSTITUTE

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Univ. of	Akron, Ohio	2	Harmon Shively	H. H. Schroeder	J. T. Walther
Alabama Poly. Inst	Auburn, Ala	4	R. Mann		W. W. Hill
Alabama, Univ. of	University, Ala	4	Walter H. Croft	Harold B. Hendrix	F. R. Maxwell, Jr.
Arizona, Univ. of	Tucson, Ariz	8	W. T. Brinton	Carl Ludy	J. C. Clark
Arkansas, Univ. of	Fayetteville, Ark	7	Ned S. Muse	E. Wylie Head	W. B. Stelzner
Armour Inst. of Tech	Chicago, Ill	5	K. A. Knittel	E. Squires	D. E. Richardson
British Columbia, Univ. of	Vancouver, B. C	10	M. A. Thomas	E. M. Kershaw	E. G. Cullwick
Brooklyn, Poly. Inst. of	Brooklyn, N. Y	3	George Morton	F. Anderson	Robin Beach
Bucknell Univ	Lewisburg, Pa	2	O. R. Sterling	P. Hort	W. K. Rhodes
Calif. Inst. of Tech	Pasadena, Calif	8	A. W. Strong	J. E. Girard	R. W. Sorensen
Calif., Univ. of	Berkeley, Calif	8	Harry C. Stanley	Louis Zable	L. E. Reukema
Carnegie Inst. of Tech	Pittsburgh, Pa	2	M. W. Smedberg	G. H. Ikola	G. Porter
Case Sch. of Ap. Science	Cleveland, Ohio	2	G. A. Sanow	Irwin J. Rand	H. B. Dates
Catholic Univ. of America	Washington, D. C	2			T. J. MacKavanagh
Cincinnati, Univ. of	Cincinnati, Ohio	2	F. F. Osterholtz	Henry Suter	W. C. Osterbrock
Clarkson College of Tech	Potsdam, N. Y	1	E. S. Whitaker	C. L. Brown	A. R. Powers
Clemson Agri. College	Clemson College, S. C	4	C. E. Jarrard	G. A. Douglass	S. R. Rhodes
Colorado, State Agri. College	Ft. Collins, Colo	6	Henry Wamboldt	Elroy Schock	F. L. Poole
Colorado, University of	Boulder, Colo	6	R. Partington	John Buffo	W. C. DuVall
Cooper Union	New York, N. Y	3	H. Grissler	A. B. Mundel	A. J. B. Fairburn
Cornell University	Ithaca, N. Y	1	C. O. Dean	Wm. E. Brainard	E. M. Strong
Denver, Univ. of	Denver, Colo	6	Harry H. Ward	Fay Olmsted	R. E. Nyswander
Detroit, Univ. of	Detroit, Michigan	5	W. R. Moyers	L. F. Ross	H. O. Warner
Drexel Inst	Philadelphia, Pa	2	E. K. Oliver	G. R. Bowers	E. O. Lange
Duke Univ	Durham, N. C	4	L. R. Ransom	A. L. de Bruyne	W. J. Seeley
Florida, Univ. of	Gainesville, Fla	4	C. V. Booth	E. Menendez	Joseph Weil
Georgia School of Tech	Atlanta, Ga	4	B. L. Palmer	H. A. List	T. W. Fitzgerald
Harvard University	Cambridge, Mass	1	J. H. Wright	P. R. Lincoln	C. L. Dawes
Idaho, Univ. of	Moscow, Idaho	9	F. Meneely	Clyde Ross	J. H. Johnson
Iowa State College	Ames, Iowa	5	George A. Estel	A. W. Chewning	F. E. Johnson
Iowa, State Univ. of	Iowa City, Iowa	5	J. Westley Campian	D. A. Cozine	E. B. Kurtz
Kansas State College	Manhattan, Kansas	7	E. F. Peterson	H. E. Trekell	R. G. Kloeffler
Kansas, Univ. of	Lawrence, Kansas	7	J. Worner	F. Shiner	D. C. Jackson, Jr.
Kentucky, Univ. of	Lexington, Ky	4	S. M. Worthington	B. G. Crosby, Jr	W. E. Freeman
Lafayette College	Easton, Pa	2	A. H. Edmondson	H. H. Jones	Morland King
Lehigh Univ	Bethlehem, Pa	2	P. W. Seal	L. R. Wanner	N. S. Hibshman
Lewis Inst	Chicago, Ill	5	C. B. Frellsen	K. J. Sinclair	F. A. Rogers
Louisiana State Univ	Baton Rouge, La	4	Fred H. Fenn	R. A. Crain	M. B. Voorhies
Louisville, Univ. of	Louisville, Ky	4	John G. Lips	Wm. E. Bailey	S. T. Fife
Maine, Univ. of	Orono, Maine	1	Monroe E. Moon	Lincoln O. Spencer	W. E. Barrows, Jr.
Marquette Univ	Milwaukee, Wis	5	David Becker	Edward Halback	Edward Kane
Massachusetts Inst. of Tech	Cambridge, Mass	1	G. S. Brown	Fred J. Elser	W. H. Timbie
Michigan Col. of Mining and Tech	Houghton, Mich	5	A. G. Rogers	M. D. Crowell	G. W. Swenson
Michigan State College	East Lansing, Mich	5	Robert Dearing	J. J. Clark	W. A. Murray
Michigan, Univ. of	Ann Arbor, Michigan	5	A. D. Forbes	G. Muffly	B. F. Bailey
Milwaukee, School of Eng. of	Milwaukee, Wis	5	William P. Gainer	H. F. Volkmann	Oscar Werwath
Minnesota, Univ. of	Minneapolis, Minn	5	Wesley D. Taylor	R. C. Cady	J. H. Kuhlmann
Mississippi Agri. & Mech. Col	A. & M. College, Miss	4	J. M. Leigh	J. T. Young	L. L. Patterson
Missouri School of Mines & Met	Rolla, Mo	7	J. D. Shelton	G. L. Leisher	I. H. Lovett
Missouri, Univ. of	Columbia, Mo	7	R. L. Young	R. Osadchey	M. P. Weinbach
Montana State College	Bozeman, Mont	9	Bruce Mull	Wm. McKay	J. A. Thaler
Nebraska, Univ. of	Lincoln, Nebraska	6	Phil Ehrenhard	Wm. M. Ely	F. W. Norris
Nevada, Univ. of	Reno, Nevada	8	Francis Headley	Eugene Tucker	S. G. Palmer
Newark College of Eng	Newark, N. J	3	Wm. R. Ackor	John G. Woelking	J. C. Peet
New Hampshire, Univ. of	Durham, N. H	1	A. K. Whitcomb	Carl B. Evans	L. W. Hitchcock
New Mexico, Univ. of	Albuquerque, New Mexico	7	C. E. Henderson	S. M. Pelatowski	F. M. Denton
New York, Col. of the City of	New York, N. Y	3	C. Hackemeister	Howard Klein	Harry Baum
New York Univ	Univ. Heights, New York, N. Y	3	G. J. Helis	M. Bogstahl	J. L. Arnold
North Carolina State College	Raleigh, N. C	4	R. C. Kirk	J. H. Mauney	R. S. Fouraker
North Carolina, Univ. of	Chapel Hill, N. C	4	G. D. Thompson	Charles Hayes	J. E. Lear
North Dakota Agri. College	Fargo, N. D	6	R. Stockstad	R. Carlson	H. S. Rush
North Dakota, Univ. of	Grand Forks, N. D	6	B. J. Shields	Mark Scarff	H. F. Rice
Northeastern Univ	Boston, 17, Mass	1	A. K. Wright	P. H. Townsend	W. L. Smith
Notre Dame, Univ. of	Notre Dame, Ind	5	Earl Brieger	H. J. Perry	J. A. Caparo
Ohio Northern Univ	Ada, Ohio	2	D. Pringle	H. L. Hartman	W. Krausnick
Ohio State Univ	Columbus, Ohio	2	G. F. Leydorf	R. W. Steenrod	F. C. Caldwell
Ohio Univ	Athens, Ohio	2	H. Swigart	H. Adcock	A. A. Atkinson
Oklahoma Agri. & Mech. Col	Stillwater, Okla	7	Paul H. Foster	Merle C. Brady	A. Naeter
Oklahoma, Univ. of	Norman, Okla	7	G. S. Hammonds	William J. Fell	F. G. Tappan
Oregon State College	Corvallis, Oregon	9	H. Glen Barnett	Gordon N. Smith	F. O. McMillan
Pennsylvania State College	State College, Pa	2	S. E. McKibben	E. L. Johnston	L. A. Doggett
Pennsylvania, Univ. of	Philadelphia, Pa	2	Wm. D. Bruce	C. V. Castle	C. D. Fawcett
Pittsburgh, Univ. of	Pittsburgh, Pa	2	W. J. Howell	R. H. Kernahan	H. E. Dyche
Pratt Inst	Brooklyn, N. Y	3	J. E. Cook	J. A. Hoag	C. C. Carr
Princeton Univ	Princeton, N. J	2	F. L. Thomson	Ernest E. George	M. MacLaren
Purdue Univ	Lafayette, Ind	5	A. Simon	C. B. Bruse	A. N. Topping
Rensselaer Poly. Inst	Troy, N. Y	1	C. E. Keeler	A. M. Lockie	F. M. Sebast
Rhode Island State College	Kingston, R. I	1	G. Z. Verros	M. R. Lettieri	Wm. Anderson
Rose Poly. Inst	Terre Haute, Indiana	5	Robert S. Roach	C. E. White	C. C. Knipmeyer
Rutgers Univ	New Brunswick, N. J	3	F. T. Kent, Jr	R. C. Howell	P. S. Creager
Santa Clara, Univ. of	Santa Clara, Calif	8	William Warren	L. W. Thorpe	E. F. Petersen

STUDENT BRANCHES OF THE INSTITUTE—*Continued*

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
South Carolina, Univ. of	Columbia, S. C	4	L. E. Rankin	W. Dickerson	T. F. Ball
South Dakota State Sch. of Mines	Rapid City, S. D	6	C. Laws	A. M. Bjerke	J. O. Kammerman
South Dakota, Univ. of	Vermillion, S. D	6	Myron Cole	Carl Bauman	B. B. Brackett
Southern California, Univ. of	Los Angeles, Calif	8	A. E. Mathews	M. C. Marshall	Wm. G. Angermann
Southern Methodist Univ	Dallas, Texas	7	F. H. Gable	P. Lindsley, Jr	H. F. Huffman
Stanford Univ	Stanford University, Calif	8	V. Siegfried	G. E. J. Jamart	T. H. Morgan
Stevens Inst. of Tech	Hoboken, N. J	3	G. J. Costello	E. Starzec	F. C. Stockwell
Swarthmore College	Swarthmore, Pa	2	Lewis Fussell, Jr	Robert H. Lamey	L. Fussell
Syracuse Univ	Syracuse, N. Y	1	Donald Robinson	W. Kleppinger	C. W. Henderson
Tennessee, Univ. of	Knoxville, Tenn	4	A. M. Howery	B. A. Cogbill	J. G. Tarboux
Texas Agri. & Mech. Col	College Station, Tex	7	T. M. Sowell	E. A. Stobart	H. C. Dillingham
Texas Tech. College	Lubbock, Texas	7	Walter Burns	Everitt Dison	Wm. J. Miller
Texas, Univ. of	Austin, Texas	7		D. Sussin	J. A. Correll
Utah, Univ. of	Salt Lake City, Utah	9	Fred Lundberg	Ray Bohne	J. H. Hamilton
Vermont, Univ. of	Burlington, Vt	1	R. F. Bigwood	P. H. Thomas	L. P. Dickinson
Virginia Military Inst	Lexington, Va	4	G. R. Shell	C. L. Wills	S. W. Anderson
Virginia Poly. Inst	Blacksburg, Va	4	C. V. West	R. E. McDaniel	Claudius Lee
Virginia, Univ. of	University, Va	4	G. G. Quarles	T. J. Peterson	W. S. Rodman
Washington, State Col. of	Pullman, Wash	9	L. Engvall	E. W. Graf	O. E. Osburn
Washington Univ	St. Louis, Mo	7	J. Pillsbury	P. Grivet	H. G. Hake
Washington, Univ. of	Seattle, Wash	9	K. H. Ellerbeck	F. Buckman	G. L. Hoard
West Virginia Univ	Morgantown, W. Va	2	P. J. Johnson	C. F. Stewart	A. H. Forman
Wisconsin, Univ. of	Madison, Wis	5	A. G. Woodford	T. N. Racheff	C. M. Jansky
Worcester Poly. Inst	Worcester, Mass	1	Albert M. Demont	William Sinclair	J. O. Phelon
Wyoming, Univ. of	Laramie, Wyo	6	J. Earl Mowry	Cyril F. Horton	G. H. Sechrist
Yale Univ	New Haven, Conn	1	E. R. Eberle	L. A. Autuori	W. B. Hall
Total 107					

AFFILIATED STUDENT SOCIETY

Brown Engineering Society..........**Brown Univ., Providence, R. I.**

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(March 1931)

Number	Author	Title
☐ **30-163**	H. M. Kraner	Electrical Porcelain
☐ **30-177**	M. D. Ross	The Application of Hydrogen Cooling to Turbine-Generators
☐ **30-178**	R. B. George	Power Transformer Noise, Its Characteristics and Reduction
☐ **30-181**	E. E. George	Operating Experiences with Reactance Type Relays
☐ **31-18**	Edward L. Moreland	Lackawanna Suburban Electrification
☐ **31-21**	W. H. Harrison and A. E. Silver	Trends in Telephone and Power Practise as Affecting Coordination
☐ **31-24**	J. C. Martin and H. L. Huber	Status of Cooperative Work on Joint Use of Poles
☐ **31-34**	R. C. Hitchcock	Traffic Control by Light Beams

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its JOURNAL publication. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name..

Address..

Please order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Industrial Notes

The Ward Leonard Electric Company, Mount Vernon, N. Y., has appointed the Beedle Equipment Company as sales representative in the Cincinnati and Dayton districts. Offices are located at 1309 Union Trust Building, Cincinnati, Ohio.

Weyerhaeuser Appoints Ray V. Clute.—According to a recent announcement, Ray V. Clute has been appointed manager of cedar pole sales of the Weyerhaeuser Sales Company with headquarters at Chicago. He has been associated with the company since 1916.

New Circuit Breaker.—A new indoor oil circuit breaker with enclosed type mechanism and all poles in one tank, known as type DR-25, has been developed by the Condit Electrical Mfg. Corporation, Boston. This breaker offers the features of non-oil-throwing, greater clearances, quick clearing operation, small space requirements and provision for venting gases. It is furnished three or four pole, manually or electrically operated for 600, 800 and 1200 amperes at 15,000 volts. The estimated interrupting capacity is 2500 amperes at 15,000 volts.

Construction Begins on G-E Cleveland Plant.—Construction of a $1,000,000 plant, the first unit of an extensive development in Cleveland by the General Electric Company has been started by the Austin Company, engineers and builders of Cleveland, and will be completed by August 1. A definite upturn in business and the fact that building costs are the lowest in years were factors leading to the decision to start expansion projects at this time. When completed the new plant will employ 1,000 workers. The project will be erected on a 23-acre site in Euclid, ten miles east of downtown Cleveland, and about three miles from Nela Park, the extensive research laboratories of the company. In the plant will be made all of the wire filament for incandescent lamps, in addition to all gases used in the works of the lamp company.

Trade Literature

Waterwheel Generators.—Bulletin GEA-820A. Describes vertical waterwheel-driven generators. Such units range in size from 30 to 77,500 kv-a. General Electric Co., Schenectady, N. Y.

Arc Welding Supplies.—Bulletin 3304, 20 pp. Describes welding rods, shields, holders, cables, protective clothing, and other accessories. The Lincoln Electric Company, Cleveland.

Turbine-Generator Units.—Bulletin 1835-A. Describes Westinghouse 3600 r. p. m. steam-turbine-generator units. Westinghouse Electric & Manufacturing Company, East Pittsburgh.

Insulator Glaze.—Bulletin, 10 pp. Treats of the glaze of porcelain insulators and its influence on insulator life and strength. Locke Insulator Corporation, So. Charles and Cromwell Streets, Baltimore.

Synchronous Condensers.—Bulletin GEA-1337, 20 pp. Describes small synchronous condensers for improving power factor and for maintaining correct voltage in industrial plants. General Electric Company, Schenectady, N. Y.

Vulcanized Fibre.—Bulletin, 40 pp. Describes "Diamond" vulcanized fibre. The process of manufacture is illustrated and uses of the product, widely applicable in electrical fields, are illustrated. Continental-Diamond Fibre Company, Newark, Del.

Motors.—Bulletin 169, 8 pp. Describes Wagner slip-ring motors, four different types, speed torque characteristics and control equipment necessary for starting. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis.

Insulated Aluminum Conductors.—Bulletin, 16 pp. Describes "Alectral" insulated aluminum wires, cables and fittings. The advantages of the new type conductors for various applications are outlined. General Cable Corporation, 420 Lexington Avenue, New York.

Phosphor Bronze—Nickel Bronze.—Bulletins, each 32 pp., describe various alloys of these metals, their characteristics and uses. The Riverside Metal Company, Riverside, N. J.

Relays.—Bulletin GEA-970B, 48 pp. Describes type PQ relays, designed primarily for alternating-current service and for use in protecting circuits and connected apparatus in general, in cases of overcurrent and short circuit. General Electric Company, Schenectady, N. Y.

Battery Locomotives — Transfer Cars.—Bulletin 1237, 16 pp. Describes storage battery locomotives, special cars for transportation of transformers, coal and ash cars, turn tables and other equipment supplied to central stations and large industrial power plants. The Atlas Car & Manufacturing Company, Cleveland.

Welded Pipe Gas Lines.—Bulletin 510, 52 pp. Describes "Smithwelded" pipe for gas lines. The bulletin includes detailed methods for determining design, stresses, weights, costs, etc. Photographs are included of some of the installations, which range in length to over 700 miles. A. O. Smith Corporation, Milwaukee.

Ash Conveyors.—Bulletin, 20 pp. Describes "Nuveyor" ash conveyor systems, designed primarily to meet the requirements of clean and economical ash disposal for large power plants. The capacities of such systems range from 3 to 30 tons per hour, and may be used in conjunction with either stoker-fired or pulverized fuel firing. United Conveyor Corporation, Old Colony Building, Chicago.

Smoke Recorder.—Circular. Describes the new L & N smoke recorder. The recording installation consists of a measuring chamber at the stack or breeching, a chart recorder at any convenient location, and an indicator at the boiler. For central stations these devices assist in meeting ordinance requirements, maintaining minimum smoke density and inducing economy in firing. Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia.

Fans.—Bulletin 41, 12 pp. Describes "Century" fans for alternating and direct-current, stationary, oscillating, ceiling and ventilating fans. Included in the bulletin is a new 8-in. one-speed fan for alternating current; also the "Reversair" 36-in. and 60-in. a-c. ceiling fans in which the direction of the rotation of the fan may be reversed, permitting either upward or downward air delivery. Century Electric Company, 1806 Pine Street, St. Louis.

Street Lighting.—Catalog 218-A, 126 pp., "Utilitarian Street Lighting Equipment," and catalog 218-B, 100 pp. "Ornamental Street Lighting Equipment." The former publication describes types of street lighting equipment in which the current is carried to the lighting units by overhead wiring, to distinguish installations of this character from "ornamental" street lighting systems, in which use is made of underground cable construction. Each of these publications includes general information regarding street lighting installations, descriptions and photographs of various street lighting units, standards and street lighting accessories. Westinghouse Electric & Manufacturing Company, East Pittsburgh.

Electrical Engineering

THE

JOURNAL of the A. I. E. E.

Volume 50 APRIL, 1931 Number 4

Published Monthly by the

AMERICAN INSTITUTE
of
ELECTRICAL ENGINEERS

33 West 39th Street, New York

Copyright 1931

WILLIAM S. LEE, *President*
F. L. HUTCHINSON, *National Secretary*

PUBLICATION COMMITTEE
W. S. GORSUCH, *Chairman*
H. P. CHARLESWORTH A. E. KNOWLTON
F. L. HUTCHINSON E. B. MEYER

PUBLICATION STAFF
GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

Entered as second class matter at the N. Y. Post Office, May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

Permission is given to reprint any Institute article or paper provided full credit is given.

The Institute is not responsible for any statements made or opinions expressed in its publications.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America.

In This Issue—

Front Cover

An interesting and unusual view of one of the seven 40,000-kva. 81.8-r. p. m. generators in the Conowingo (Md.) hydroelectric plant.

Electric Communication and the New York Stock Exchange 255
By DEAN K. WORCESTER, *New York Stock Exchange*

Color Console for Theater Lighting 259

Development Trends in Circuit Interrupters . . 260
By J. B. MACNEILL, *Westinghouse Electric & Manufacturing Company*

Current Collection in Hydrogen Atmosphere . . 266
By R. M. BAKER, *Westinghouse Electric & Manufacturing Company*

Evolving a Modern Protective Relay System . . 268
By E. R. STAUFFACHER, *Southern California Edison Company, Ltd.*

Resistance Welding Improves Motor Frames . . . 273
By MALCOLM THOMSON, *General Electric Company*

Low-Frequency Induction 276
By R. N. CONWELL, *Public Service Electric & Gas Company, and* H. S. WARREN, *American Telephone & Telegraph Company*

Noise-Frequency Induction 279
By H. L. WILLS, *Georgia Power Company, and* O. B. BLACKWELL, *American Telephone & Telegraph Company*

—Turn to Next Page—

Interference in Ocean Cable Telegraphy 281

By J. W. Milnor, *Western Union Telegraph Company*

Transforming Reactor Improves D-C. Arc Welding 283

By S. R. Bergman, *General Electric Company*

Electricity in Modern Dairy Plants 285

By A. J. Dreux, *Rieck-McJunkin Dairy Company, and* H. C. Brunner, *Westinghouse Electric & Manufacturing Company*

Cracking Oil by Electricity 288

By Herbert R. Rowland, *Moody Engineering Company*

Field Tests on Thyrite Arresters 290

By K. B. McEachron *and* E. J. Wade, *both of the General Electric Company*

Vertical A-C. Distribution Networks 292

By A. H. Kehoe, *United Electric Light & Power Company, and* Bassett Jones, *Meyer, Strong & Jones*

News of Institute and Related Activities ◆ ◆ ◆ ◆ **296**

Local Institute Meetings 308

Employment Notes 316

Membership 318

Engineering Literature 318

Industrial Notes 324

CORRECTION. In "Light Beams Operate Traffic Signals," by R. C. Hitchcock (March issue), the third paragraph, fifth line, page 183, should read, "lenses and resulting *in* (not *from*) the apparatus going on. . . ."

◆

DEMONSTRATING Institute activities in the advancement of electrical engineering one has only to review the subjects on the winter convention program, partial discussion for which appears on *page 299*, also papers given at the recent district meeting at Pittsburgh (*page 296*) and the tentative program for the Rochester meeting (*page 302*).

◆

SINCE the low-voltage a-c. distribution network has already proved its reliability in sections where high load densities prevail, it seems natural to think of this system being developed *vertically* to meet the load demands of very tall buildings. A. H. Kehoe, of the United Electric Light and Power Company is well qualified to give information on this subject having been in responsible charge of the development work on vertical networks since their inception. Basset Jones of Meyer, Strong & Jones, New York City a coauthor with Mr. Kehoe, has for many years been associated with building illumination and power problems. (*See page 292*)

◆

"CRACKING" low-grade oils by electricity to convert them into usable gasoline and other volatile fluids has been achieved through perseverance and super-detailed experimentation. This has been made the subject of a paper which H. R. Rowland has presented before the Institute's Kansas City Section. (*See page 288*)

◆

THE ELECTROPURE method of pasteurizing, in which an electric current is actually passed through the milk itself is the subject interestingly discussed by A. J. Dreux of the Rieck-McJunkin Dairy Company of Pittsburgh (where the process is in practical use) and H. C. Brunner, general engineer of the Westinghouse Electric & Manufacturing Company. (*See page 285*)

◆

DEVELOPING a protective relay system for long transmission lines where stability plays such a master role, is a difficult problem indeed. E. R. Stauffacher, electrical protective engineer of the Southern California Edison Company, Ltd., reviews a decade of his experiences in this work on the lines in Southern California where the situation has been further complicated by rapid and extensive system growth. (*See page 268*)

◆

OF no minor importance is the consideration of noise-frequency induction which constituted part of a symposium given at the Institute's winter convention the major features of which are abstracted in this issue. This is especially significant in view of the coordination problems involved between power and communication circuits represented respectively by H. L. Wills of the Georgia Power Company, and O. B. Blackwell of the American Tel. & Tel. Co. (*See page 279*)

Electric Communication and the New York Stock Exchange

Electric communication has grown to be an extremely important aid in the speedy transaction of business. This is especially true of the New York Stock Exchange with its hundreds of private telephone lines, thousands of high-speed tickers, and a telephone quotation bureau which handles as many calls per hour as a large central telephone office.

By Dean K. Worcester

Associate A. I. E. E.

Assistant Secretary, New York Stock Exchange

IT IS DIFFICULT to imagine a business or industry more dependent upon electric communication systems than that of a stock exchange. Perhaps the underlying reason is that no man can succeed in this business whose word is not as good as his bond; and so the telephone and the telegraph handle innumerable transactions which would otherwise require the services of the typewriter and the postman. In any event, the growth of the electrical transmission of intelligence since 1867, when the first stock ticker was placed in the New York Stock Exchange, and 1878, when the first telephone was installed there, has been rapid and continuous; and although the Exchange founded in 1792 has had the benefits of these devices for less than half of its history, one does not like to contemplate what would result today if these facilities were suddenly taken from it.

Many persons, especially communication engineers, are familiar with the great network of wires that connects Wall Street with brokerage offices, banks, investment houses, and similar institutions throughout the country. The myriad of lines, however, which enter the group of buildings comprising the Stock Exchange seem to be clothed in mystery. For this, two factors are probably mainly responsible. First, the impracticability of admitting the public onto the trading floor itself, where most of these wires have either their beginning or ending; and second, the inexorable supervision maintained by the Exchange over these vital wire connections, to prevent their improper use by gentry of uncertain antecedents and motives.

BUSINESS OF THE EXCHANGE

The Exchange itself, be it clearly understood, does not buy or sell securities; it determines no prices, has no official quotations, and keeps no record of the transactions made upon its floor. It exists for the purposes set forth in Article I of its Constitution; namely, "to furnish exchange rooms and other facilities for the convenient transaction of their business by its members; to maintain high standards of commercial honor and integrity among its members; and to promote and inculcate just and equitable principles of trade and business."

The business which the members of the Exchange transact upon its floor is the making of contracts to purchase or sell such securities as are approved and admitted to dealing by a committee of the Exchange chosen for this purpose.

The rooms which the Exchange provides comprise at present a "board room" which, with its annex, has an area of about 22,000 sq. ft., and a "bond room" with an area of some 6,000 sq. ft. In these rooms some 1,350 stocks and 1,500 issues of bonds are dealt in. Contracts may be made only by members, (of whom there are now 1,352), and this power may not be delegated to anyone save another member. About 1,000 members are present each day upon the floor. Contracts are oral only, no written contracts nor memoranda being exchanged upon the floor. Settlement of contracts by the delivery of securities and payment of money is handled elsewhere.

Among the facilities provided by the Exchange to aid its members in the transaction of their business upon the floor are:

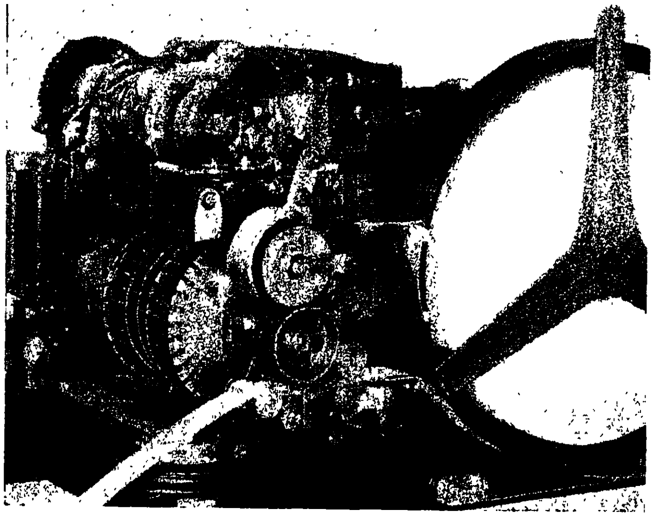
1. Approximately 1,400 telephone spaces located around the edge of the trading floor where members may install private-wire connections to their offices or to the offices of other members. At these spaces members may also station their own telephone clerks who attend to the handling of orders, reports, and other business over the wires, leaving the member free to execute orders—an invaluable assistance.

2. A telephone quotation bureau, to which the bid and asked prices of stocks are continuously reported by a number of employees on the floor. Members having nearby offices may be connected by private telephone lines with this bureau, and may thus obtain within a few seconds the price bid for a stock, and the price at which it is offered, irrespective of whether or not a sale has recently taken place.

3. About 1,100 employees of the Exchange regularly stationed upon the floor carry messages, transmit written orders through pneumatic tubes (of which there are 35 miles beneath the floor), take down reports of transactions and cause them to be printed on the ticker tape, report bid and asked prices to the telephone quotation bureau, and perform other services.

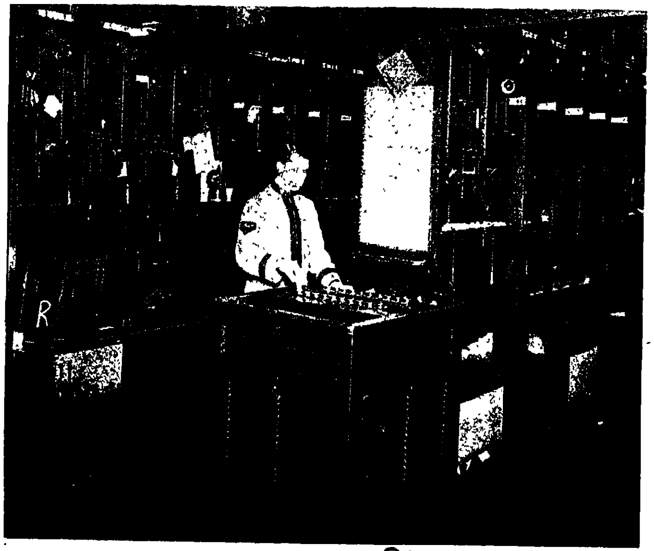
4. Ticker service which is rendered by a subsidiary, the New York Quotation Company, to members of the Exchange located south of Chambers Street in Manhattan. Under a non-exclusive contract the ticker quotations are made available to the Western Union Telegraph Company, by which they are retransmitted to other members and approved non-members located in the United States, Canada, and Cuba.

Written especially for ELECTRICAL ENGINEERING, based upon an address delivered before the Communication Group, New York Section, A. I. E. E., Jan. 6, 1931.



© New York Stock Exchange

New high-speed stock ticker with cover removed



© New York Stock Exchange

Section of private-wire telephone booths. Pneumatic-tube station shown in the foreground

Note that many of the receivers are not replaced on their hooks but are simply dropped and left hanging. The receiver cords have been looped around the hooks, their weight being sufficient to pull the hooks down and thereby break the connection

The procedure by which an order to buy or sell stock is normally handled is outlined in the following.

HANDLING AN ORDER

An order received in a member's office is telephoned to the floor over one of the private lines and taken down on an order slip by the member's telephone clerk. The clerk summons his broker by means of an extensive annunciator system and gives him the order. The broker then goes to the point on the floor at which trading is done in the stock in question, each stock having its own definite location. Having bought the stock, or sold it, as the case may be, he notes on the slip the name of the member or firm with whom he has traded, and the price. He then returns the slip to the telephone clerk who in turn reports the execution to his office over the private wire.

It is thus evident that the system of private wires which connects the floor with the offices of members is an indispensable link in the handling of their business. There are about 2,300 such wires, each entirely independent of the others, and it is estimated that on a moderately active day more than 2,000,000 calls are made over these wires during the five hours of trading. Obviously, a member whose communications are interrupted, delayed, or confused, even for a few minutes, would find himself for the time being practically unable to do business.

The simple private telephone line, consisting essentially of a pair of conductors having at each end a telephone instrument, a bell, and a ringing key, has proved to be admirably suited for this exacting service. It combines to a high degree the fundamental requirements of simplicity, speed, and surety.

There can be no misunderstanding as to the identity of the person on the other end of the line, for no switching takes place; the possibility of breakdown is made as remote as possible; and messages can be passed as fast as people can talk. Furthermore, any intermediary switching device would make it less difficult for unauthorized and unscrupulous persons to get into communication with the Exchange floor; and so it is a rigid requirement of the Exchange that all lines shall be private, and shall terminate at each end either in a separate instrument, or in a simple key-set, turret, or monitor, which, if used, shall be restricted exclusively to the use of such lines. The lines themselves are installed by the New York Telephone Company under a contract with the Exchange, and may be connected, moved, or disconnected, only by an order from the Exchange.

HIGH-SPEED TICKER SYSTEM

A wholly different communication problem is presented by the ticker system.

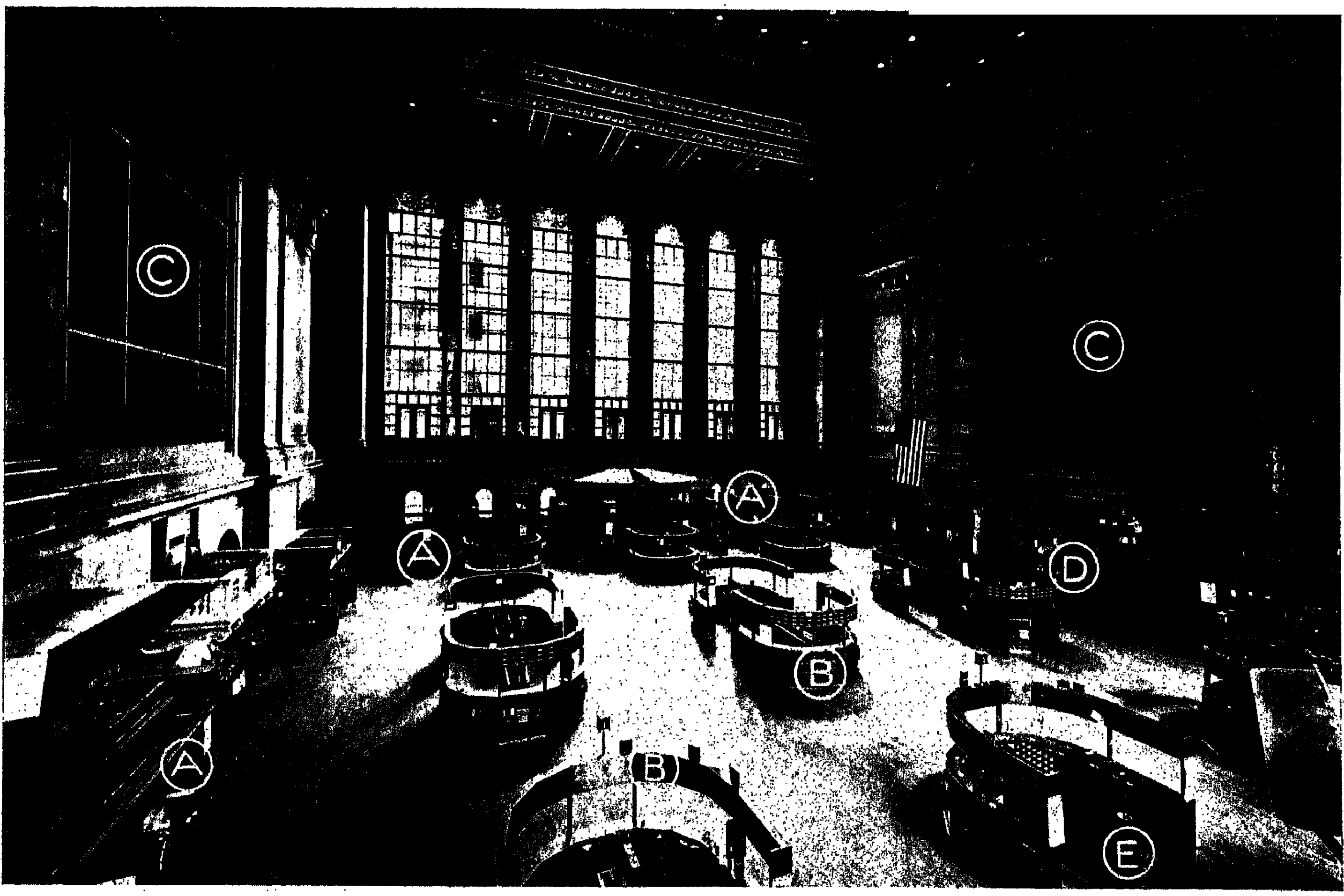
The present ticker instrument is simply a high-speed printing telegraph, controlled over a single-wire circuit, and driven from a local power source, usually the subscriber's lighting system. The New York Quotation Company owns and operates approximately 2,500 tickers, together with underground conductors, transmitting apparatus, and other equipment, all located as described, in southern Manhattan. This company has exclusive access to the Exchange floor for obtaining reports of transactions. The Western Union Telegraph Company obtains quotations from a New York Quotation Company ticker; re-transmission is effected by that company by means of an ingenious double-manual keyboard which without disturbing the sequence of quotations enables two operators to cooperate in copying them from the tape, the operating speed of 500 characters per minute being far too great for one person to handle.

Among the 1,100 Exchange employees stationed on the floor are more than 200 reporters who make note of each transaction as it occurs, writing on a slip of paper the name of the security, (abbreviated, of course), the amount sold, and the price. These slips are dispatched without delay to a transmitting operator, who sits at a perforator keyboard and perforates a paper tape with the code corresponding to the characters which are to be printed. There are six such transmitting stations, which were formerly located at separate points on the floor. Recently these have been brought together on an elevated platform, to which point the report slips are sent through pneumatic tubes.

The six perforated tapes are summarized by a reperforator on a master tape which passes through a master transmitter and operates the ticker system. At each of the six stations just mentioned a ticker is provided, and in order to detect any errors which may have crept in, the report slips after being transcribed by the keyboard operator are immediately and carefully compared with the printed tape.

The Exchange uses every effort to make the ticker tape an accurate and punctual record of what takes place on the floor; but in spite of safeguards and notwithstanding the high level of mechanical and electrical precision at which the ticker system is maintained, errors must sometimes occur. Consequently, the tape cannot be, and is not, looked upon as an official record but merely as the best record that it is possible to keep.

It is regrettable that the historic days of 1929, with the resulting market activity which continued into the early summer of 1930, did not hold themselves in abeyance a few months more; for on September 2, 1930, the new high-speed ticker system operated as such for the first time, but since that date has had little opportunity to test its capacity in a really active market. The old ticker system printing 275 characters per min. found difficulty in keeping abreast of a four-million-share day,



© New York Stock Exchange

General view of trading floor of the New York Stock Exchange showing (A) private-wire telephone booths; (B) trading posts; (C) annunciator call-boards for brokers; (D) money desk; (E) pneumatic-tube stations connecting trading posts with telephone booths and on eight- or ten-million-share days the tape was sometimes hours behind the market.

The new ticker prints 500 characters per minute or slightly less than twice as many as the old machine. Yet its adequacy in terms of shares of stock is believed to be far greater than this two-to-one ratio. Records show that as the volume of trading increases, the number of tape impressions per hundred shares of stock sold falls off sharply, thus enabling a given number of impressions (such as the number that can be printed during one hour) to record a far larger amount of stock. For example, on a four-million-share day the average number of impressions per hundred shares is about 2.0; at eight million shares per day this figure is more nearly 1.4; and at twelve million shares, the data though they are few indicate that the coefficient is about 1.1. The reasons for this are twofold; first, the Exchange itself takes steps to abbreviate the record on the tape by omitting volume figures or by printing only the last digit and fraction of the price instead of the full price; and second, the average number of shares of stock per transaction becomes larger, yet it takes only a little more work for the ticker to record a sale of 5,000 shares than a sale of 200 shares.

In any event, the new ticker can print 150,000 characters during the five hours of trading; if the number of required impressions per hundred shares is 2.0, the ticker can thus record 7,500,000 shares; but at 1.1 impressions per hundred shares, the ticker could keep effective pace with a turnover of about 13,500,000 shares per day. Of course trading does not run at a uniform rate even for a single day; but it seems safe to expect that the ability of the new ticker to keep pace with the market will prove much greater than its printing speed alone would indicate.

© New York Stock Exchange

General view of telephone quotation bureau before installation of bulletin boards

TELEPHONE QUOTATION BUREAU

The telephone quotation bureau makes available to members' offices on short notice the latest bid and asked prices of any stock they may desire. By bid and asked prices are meant the prices at which stock can be sold (bid) or purchased (asked)—information which is obviously of considerable value to a person who contemplates placing an order to buy or sell. Prior to the early part of 1929 this could be done only by telephoning the floor via one of the private wires. A broker or page would then be sent to the place on the floor where the stock in question was being traded (often a hundred feet or more away) and in due course the quotation would be reported back over the telephone. This resulted in delay and caused serious traffic congestion upon the floor. To cure this situation, the telephone quotation bureau was established. It consists essentially of a distributing switchboard to which the offices of subscribing members are connected by private wire; a number of groups of "quotation operators" seated at tables connected by trunk groups to the distributing board; and a bulletin board for each group of operators, upon which the current bid and asked prices of a number of stocks are posted.

On the Exchange floor are over 100 "quotation boys," each of whom covers one or more stocks; any change in the bid or offer is reported to the bureau by direct telephone line, and the prices shown on the bulletin are changed to correspond. A member desiring a quotation dials a two-digit code (as the distributing board is now machine-switching) which he obtains from a printed booklet containing the names and codes of all listed stocks. A trunk is thus selected which connects the member to the group of operators before whom are posted quotations for the stock in question; he states the name of the stock wanted and receives the quotation.

Many vicissitudes were experienced during the development of this system. No basic engineering data were available. It was known only that the number of daily requests for quotations as determined by actual count upon the Exchange floor amounted to about 8,000 calls per day. Nothing was known as to how this volume might increase upon the introduction of a fast telephone service; holding times, operator's loads, and trunking requirements, could only be guessed at. A safety factor of 300 per cent was finally chosen, and the first bureau was accordingly opened early in 1929 with an estimated capacity of 24,000 calls per day. Suffice it to say that within a few months an entirely new bureau was ordered and before it could be built and placed in service the old bureau was handling 54,000 calls per day.

This new bureau opened last July is expected to take care of 20,000 calls per hour, or 100,000 per day. Incidentally, although this bureau has only about 350 incoming subscribers' lines, this hourly rate of 20,000 calls is greater than that of most major central telephone offices having as many as 10,000 lines each.

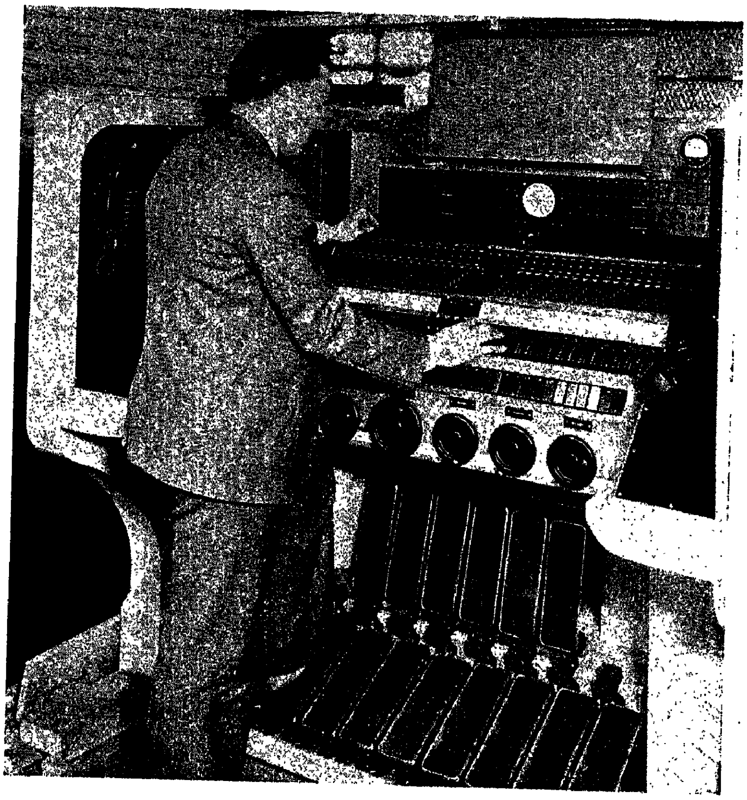
Although the new bureau like the new ticker has had little chance to give an account of itself, yet over 9,900 calls have occasionally been handled during 30 minutes.

Some interesting engineering features of the quotation bureau arise from the large number of stocks quoted (about 1,000 active and 350 inactive); the very high calling rate (over 50 calls per line per hour); the extremely short holding time (about seventeen seconds average, of which from six to eight seconds are consumed in dialing alone); and the continually changing concentration of traffic. Within half an hour some stocks are called for hundreds of times; others only once or twice a month. Some stocks which have lain dormant for months may suddenly flare up and as suddenly die, while new stocks may be added on only a few hours' notice. The equipment on the Exchange floor where the all-important information is gathered must be susceptible of uninterrupted rapid use by over 100 people without interfering with the activities of some 3,500 other people who on a busy day are very busy indeed.

Since the introduction of the telephone and electrical ticker into the New York Stock Exchange more than 50 years ago, electric communication systems have grown to be an almost indispensable link in the transaction of its business. As has been shown, the equipment making up these systems must meet the exacting requirements of fast, continuous, and dependable operation, since a failure or delay in any part would result in impeding if not completely interrupting the activities of some of the members. With the growth of the Exchange these systems have grown steadily and undoubtedly will continue to improve and expand according to the dictates of a constantly increasing volume of business.

◆ ◆ ◆

Color Console For Theater Lighting



Front of color console showing arrangement of controls

BY MEANS of vacuum tubes, a "light artist" at the "color console" of Cleveland's Severance Memorial Hall has hue and intensity of auditorium and stage lighting at his finger and toe tips, just as a pipe organist finds pitch and volume of sound at his command.

This unique Westinghouse lighting switchboard, built into an ordinary organ console, has the ability to "remember;" four complete scenes may be set up in advance to be called forth at will by throwing a master switch. The different scenes can form a continuous program, one scene automatically merging into the other at controlled rates. The vacuum-tube control scheme is the means of reaching for the first time the long sought goal of "proportional dimming"—that is, previously-set intensities of various groups of lamps keep their same relative brilliance while being dimmed. However, the operator at his console has every lighting effect subject to his will at all times.

Hitherto, theater-lighting switchboards have lurked in the wings, because they were too ugly and cumbersome to be placed in more desirable locations; a new means of governing the grids of vacuum tubes enabled engineers to concentrate the "nerve centers" of nearly 4,000 lighting combinations in an ordinary organ console. Such a console is portable, a 40-ft. extension cord allowing it to remain on the stage or ride the elevator platform in the orchestra pit.

This "light console" has 36 main-control drums which project ¾ in. above the face of its keyboard panel and are spaced only 15/16 in. apart. These 36 controls brighten or dim a total of 110 lighting circuits.

If the operator needs his hands for other work, or if his fingers tire, a slip of a switch transfers the intensity control to a group of nine horizontal foot-pedals. Four slanting foot pedals can be made master controls for groups of circuits. For instance, by manipulating two of these master pedals half the lights could be dimmed simultaneously while the other half increased in brilliance.

On the diagonal sides of the console are 110-cross-connecting switches for distributing the various circuits among the 36 control panels. Relays in the basement apparatus room do the actual work of connecting the proper vacuum-tube units to their associated apparatus and lamps.

Development Trends in Circuit Interrupters

Several novel circuit interrupting devices are showing possibilities of commercial importance, some representing improvements to oil circuit breakers and others indicating a possible trend toward the non-oil type of equipment. Deion, compressed-gas, expansion, vacuum, and oil breakers are discussed briefly in the light of present laboratory knowledge.

By J. B. MacNeill
Associate A. I. E. E.

Manager, Circuit Breaker Engineering Department
Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

SEVERAL of the many novel ideas for the interruption of high-powered, a-c. short circuits that have been advanced during the last two or three years present attractive features as compared with conventional equipment. Only tests and field service over a period of time can determine the proper place in the electric power industry for each development, since the various ideas presented are too dissimilar to enable the casual observer to form an opinion of relative merits.

At the same time there is a feeling among both the manufacturers and users of high-power circuit breakers that the industry is already too much burdened with complication due to voltage ratings, carrying-capacity ratings, structural arrangements, and many other features more or less special with groups of operating people. It may be conceded that the introduction of radically new forms of circuit-interrupting devices will not automatically simplify present day complication, but unless carefully supervised may only complicate the situation still further.

Generally this problem of circuit-interrupting apparatus is subdivided in two ways: first, into indoor and outdoor apparatus; and second, into low-voltage and high-voltage apparatus. In America, practically all switching equipment above 25 kv. is outdoor, so that a view of the situation is simplified by thinking of the problem in two parts; the first, indoor apparatus at 25 kv. and below, and the second, all outdoor apparatus. The merits of a proposed device to meet the requirements of these two classifications is important in connection with newer ideas.

Deion Circuit Breakers

It is only in the past few years that the cold-cathode arc has been studied, and the theory of current being carried to the cathode by positive ions diffused from a highly thermally-ionized gas layer adjacent to the cathode has been advanced in support of it.[1-4] This conception of a cold-cathode arc has been followed by considerable advance in the rupture of high-voltage circuits in air. Further research investigation[5] disclosed that after a current zero the thin layer of gas immediately adjacent to the cathode regains a rather definite dielectric strength at a rate faster than voltage restored across any practical operating circuit.

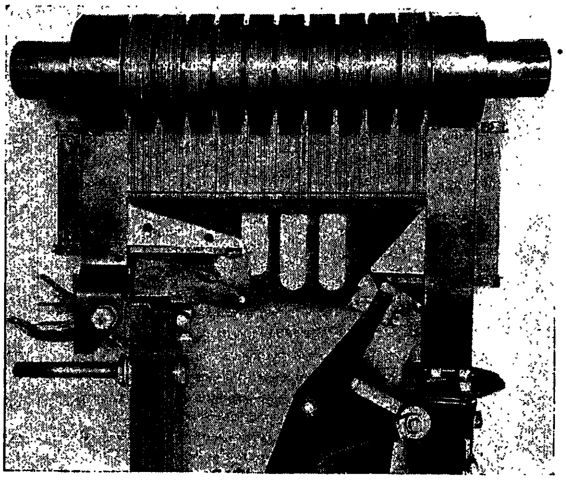


Fig. 1. Partial assembly of a 600-ampere 15-kv. deion air-break circuit breaker designed for 500,000 arc kva.

These ideas of the cold-cathode arc and the relatively high dielectric of the cathode gas layer may be considered in some respects to form the fundamental nucleus of the deion breaker.[6]

Considerable progress has been made in the past year in the development of commercial apparatus involving the deion idea. This work has been based upon laboratory tests[7], and further check by an extensive series of field tests up to 550,000 arc kva. at 12 kv.[8], and other field tests up to 800,000 arc kva. at 24 kv.

A limited number of breakers rated 500,000 arc kva. at 15 kv. has been in 12-kv. service for more than a year without difficulty. A considerable number, approximately 160 pole units, of the same rating has been placed in service during 1930 on from 11 to 13 kv. There are at present under way numerous tests on a breaker for 1,000,000 arc kva. at 15 kv. The plate unit of this breaker is shown in Fig. 2. An improved breaker designed for 1,500,000 arc kva. at 25 kv. has been built and is shown in Fig. 3. Work is well under way on a breaker for 250,000 arc kva. at 5 kv.

From "The Trend in Development of Modern Circuit Interrupters," (No. 31-3), presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

1. For references see bibliography.

By referring to Fig. 2 it is seen that a considerable modification has been made in the plate structure as compared to the older "key" form of plate shown in Fig. 1. In the newer construction each plate is provided with a vent direct from its own arcing space. This vent is much more direct than the older method of venting at the end of the arc-drawing space shown in Fig. 1, and therefore superior heat elimination after short circuit is secured. This in turn increases the rupturing capacity of a given sized plate and the number of operating cycles to which it may be subjected.

The new plate structure eliminates the large blow-in coils previously necessary on the sides of the chamber, thus making arc transfer into the plates easier by reducing complication and eliminating the possibility of voltage puncturing from the coils and magnetic circuits to the opposite polarity inside the chamber. This new design of plate has made possible the building of 25-kv. breakers in a single unit and in a space fairly comparable with 15-kv. designs.

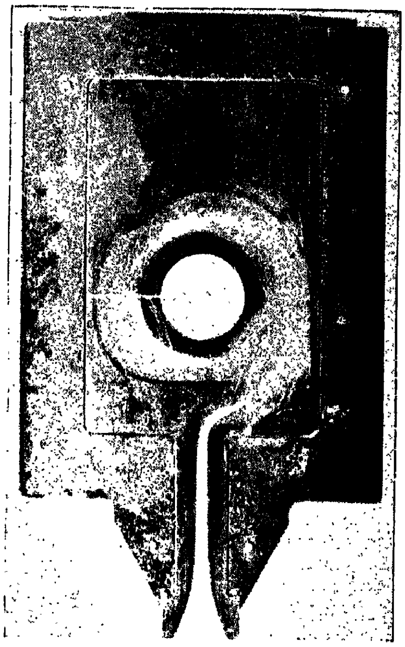


Fig. 2. A deionizing plate from a 1,000,000-kva. deion air-break unit

So far as can be seen there is no immediate limitation to the rupturing capacity of deion air breakers. Like other non-immersed switching devices, however, they are subject to the limitations of present day insulating materials. While development along this line is possible, it seems advisable for the present to limit this type of circuit breaker to 25-kv. service and below, and for the most part to indoor applications. An insulation test of 80 to 100 kv. with a breaker open or closed can be secured with reasonable construction for 25-kv. service. If atmospheric conditions are normally good, this appears sufficient giving a relatively small deposit of dirt and moisture.

COMPRESSED GAS CIRCUIT BREAKER

The idea of using compressed gas for interrupting high-voltage circuits is not new and has been worked on by several concerns. However, with the aid of adequate test facilities, the A. E. G. of Germany has sponsored this development and much progress has been made. Several technical papers by the inventors and designers of this equipment have been presented to the industry.[9] Fig. 4 shows the design of this breaker for 10-kv. service. The high-voltage circuit is made at the top of the tube through a terminal which is connected by the moving contact to the lower terminal at the bottom end of the tube. Operation is generally secured by an air cylinder fed from the same source of air pressure which gives arc rupture, and the mechanical operation of the device is so arranged that movement of contact parts and valve actions assure air pressure simultaneously with, or just previous to, the parting of contacts. There is thus no possibility of drawing a high-voltage arc without necessary pressure for rupture being present. For the purpose of assuring several repeated operations without the necessity of air from the main storage, the pressure in the air reservoir at the breaker is generally quite high. It is reported that in a typical case, an air pressure of 15 atmospheres (225 lb.) is reduced to 11 atmospheres after the first short circuit, 7 atmospheres after the second short circuit, and approximately 4 atmospheres after the third short circuit. An initial pressure of approximately 7 atmospheres is adequate, therefore, provided the pressure can be renewed after each short circuit.

The compressed-gas breaker has the advantage of an adequate supply of arc-extinguishing gas immediately available when the arc is started. It is extremely clean in operation with no liquids to be spilled and no large deposits, such as carbon, to be cleaned from contact parts. Furthermore, it seems to operate with low arc energy, and due to the use of special contact materials the depreciation of these parts is small.

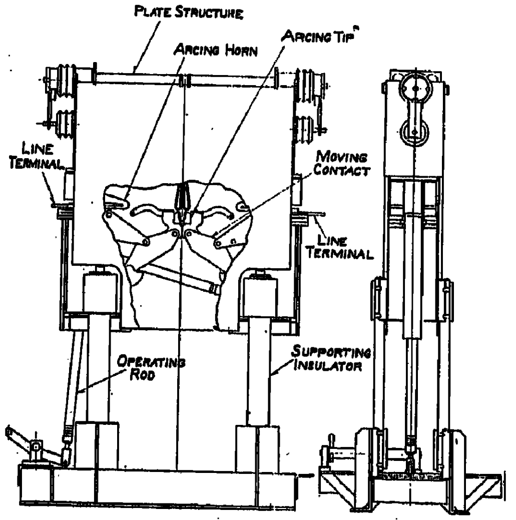


Fig. 3. Outline of single-pole unit for 1,500,000-kva. (arc) 25-kv. deion air-break circuit breaker

This device has the disadvantage of requiring at all times clean, dry air under pressure ready for instant use even though under service conditions the breaker may not operate for days or perhaps weeks. The use of air in train control where apparatus is inspected frequently and operated many times daily has reached a stage of high efficiency in this country, but the use of air valves where their operation is only infrequent has not been altogether favorable. The use of porcelain insulators subjected to sudden blasts of gas pressure may present some difficulty, and the possibility of moisture in the air affecting insulation value has to be reckoned with. The insulating limitations are similar to those of other non-immersed devices, and applications on indoor and relatively low-voltage lines present less hazard than do those for outdoor or higher voltages.

On the whole, the development of this device is a noteworthy engineering achievement and it will doubtless assume some commercial importance in the voltage classes for which it is best suited.

EXPANSION BREAKER

The development of a live-pot circuit interrupter using water is being sponsored by the Siemens-Schuckertwerke of Germany.[10] A breaker for 10-kv. service is shown in Fig. 5. A considerable number of these breakers is being manufactured for 6- and 10-kv. service, and some with ratings up to 500,000 arc kva. have been placed in successful operation in Germany during the past year.

The principle of arc interruption underlying the device is expressed in the following formula:

$$-\frac{dT}{dt} - K\frac{dV}{dt} > 0$$

Here T is the absolute temperature of the vapor in the arcing space, V is the instantaneous value of the restored voltage, and K is a value constant for a given fluid and pressure but varying with these factors. This formula states that the rate of temperature decrease must be greater than the value obtained from a constant multiplied by the rate at which voltage appears across the contacts after the current has become zero. In accordance with one possible theory offered in explanation of arc extinction, this decrease in temperature is accompanied by a corresponding condensation of moisture on the electrons, thereby increasing their inertia and making impossible a breakdown of the space between the contacts.

Fig. 5 shows a breaker of three pole units, each having a chamber mounted on a porcelain column. Above each chamber there is a triangular, hooded structure containing an operating mechanism mounted upon another column of insulating material. This unit is of the single-break-per-pole type and the moving contact operated by the rod in the rear is shown protruding from the operating mechanism chamber.

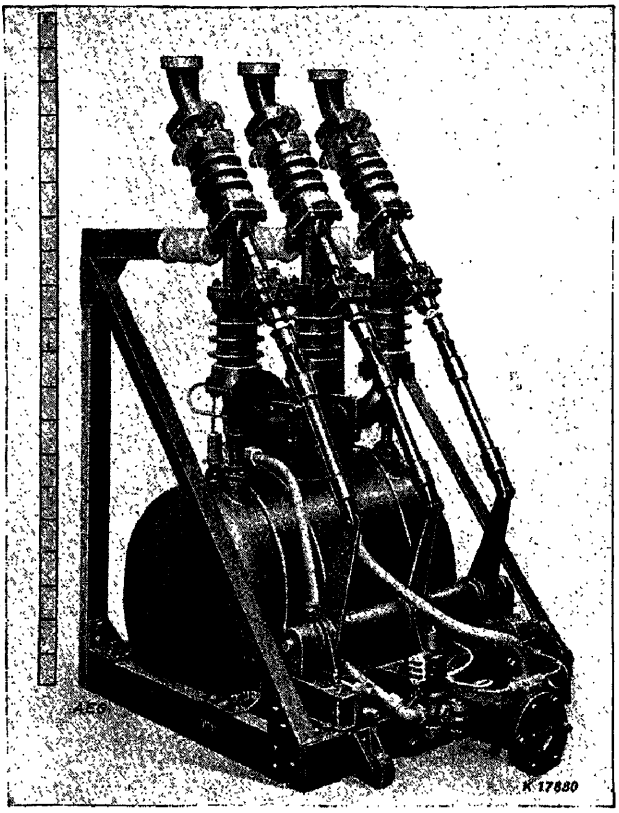


Fig. 4. Three-pole, pneumatically-operated, 600-ampere, 10-kv. breaker

The fluid chamber is divided into two parts, the inner chamber being filled with water or other liquid, and the outer chamber being a water storage space and air space to allow rapid expansion of the gas when it passes through the throat bushing of the inner chamber. Vent pipes from the outer chamber are provided for leading the expanded, moist gases safely away from the vicinity of the arc-rupturing space.

Arc interruption is secured by adiabatic expansion of the gases through the throat bushing into the outer chamber. This action causes the temperature decrease and corresponding moisture condensation in the arc stream, which in turn reduce movement of the electrons and increase the dielectric strength of the arc path.

In 1921 L. C. Nicholson developed a device similar to the expansion breaker which successfully interrupted short circuits up to 6,000 amperes at 66 kv. on a single-pole unit on the lines of the Niagara Lockport & Ontario system. Mr. Nicholson's device differed radically, however, from the expansion breaker, in that it depended upon extremely high speeds of mechanical movement for proper circuit rupture.

The engineering development of this expansion breaker has been very ingenious and many of the difficulties confronting it at the beginning have been removed. The use of water instead of oil seems to be feasible—at least for low voltages—and evaporation is not excessive. For low operating temperatures, the mixture of some compound such as glycerine with the water is necessary and apparently permissible. The question of contacts for large current capacities necessarily complicates the design but the difficulties are not insurmountable.

Since the rate of gas expansion depends upon the throat area, the design of the throat parts requires much work in order that proper deionizing action will occur over the whole range of currents and with different circuit voltage conditions. In the past, difficulty of this nature has been encountered with devices having similar characteristics; the designers feel that these problems have been successfully solved. The possibilities of explosive gas formations caused by breakdown of water into hydrogen and oxygen have been investigated and no dangerous conditions found. Naturally a device of this kind possessing the general insulation limitations of non-immersed apparatus is more suitable for lower voltages and for use indoors than for outdoors. An interesting feature of the design is the air-gap between the expansion chamber and moving contact when the breaker is open; in some cases the designers feel this may obviate the necessity of disconnecting switches, although of course it would be unwise to work on the breaker structure without such safety provision.

VACUUM BREAKERS

In general, the present indications are that while a properly constructed vacuum circuit interrupter would give a high grade of rupturing performance when interrupting low-current circuits, and may handle high voltages with very small contact separation, a material advance in vacuum technique will be necessary before this device can be developed to the point of dependable operation on high-power circuits, such as are encountered in present day switching service. At the moment, in spite of the large amount of intelligent development work done on the idea, the vacuum circuit breaker has no commercial importance.

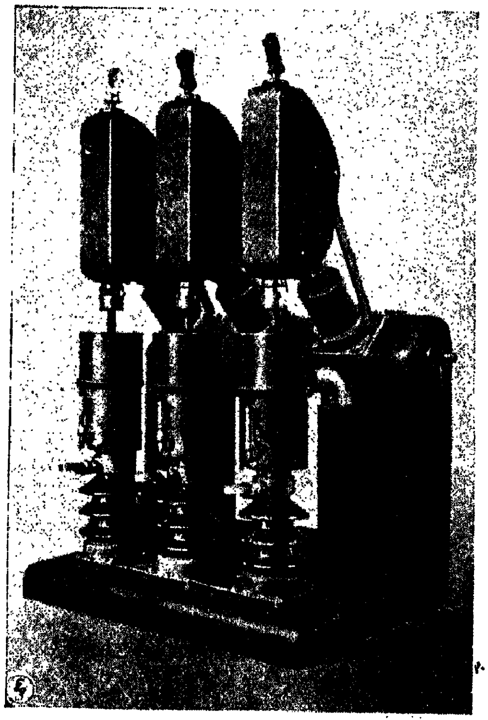


Fig. 5. Three-pole, electrically-operated, 600-ampere, 10-kv., 400,000-kva. (arc) expansion breaker

GENERAL COMMENTS ON OIL-LESS BREAKERS

In studying the work that has been done on breakers not using oil, one is forcibly impressed with the great ingenuity that has been necessary to overcome the troubles encountered. Insulation and voltage distribution quite low in the voltage range sometimes become serious questions. At times the ability of an oil insulating medium to erase broken-down arc trails, to absorb large amounts of energy by volatilization of a small amount of liquid, and to close in and cool off immediately all necessary parts, is sadly missed.

Modern non-oil devices as a whole are characterized by reduced arc energy, increased speed of switch operation, and improved contact materials. These all tend toward quieter and more satisfactory performance under short circuit, and reduced maintenance. Highly scientific work has been possible with modern facilities for test and demonstration of theories. Undoubtedly much more is known of principles of arc rupture as a result of this work.

OIL BREAKER DEVELOPMENT

It is only natural that high-power testing equipment now available to several large manufacturers should influence the design of oil breakers as well as that of oil-less breakers. Much improvement has been made along the lines of reduced arc energy, reduced arcing time, and a lower over-all switching time. Field tests have shown complete circuit-breaker operation of from six to eight cycles for 220-kv. systems, and from five to six cycles for lower-voltage systems, from the instant relay contacts are closed until the short circuit is extinguished. This performance is accompanied by arc energy constituting a fraction of that resulting with older breakers, with consequently reduced maintenance as well as assurance of adequate rupturing ability.

Advances in design continue to be reported by manufacturers of oil circuit breakers using widely different interrupting devices including multiple breaks, high-speed contacts, explosion chambers, and deion grids, and in some cases special arrangements of magnetic blowout. The limitations of all these devices have not been reached, but given similar performance in the way of high-speed action, reduced arc energy, and physical demonstration due to gas pressure, there is an inclination to favor the simpler devices as requiring less maintenance.

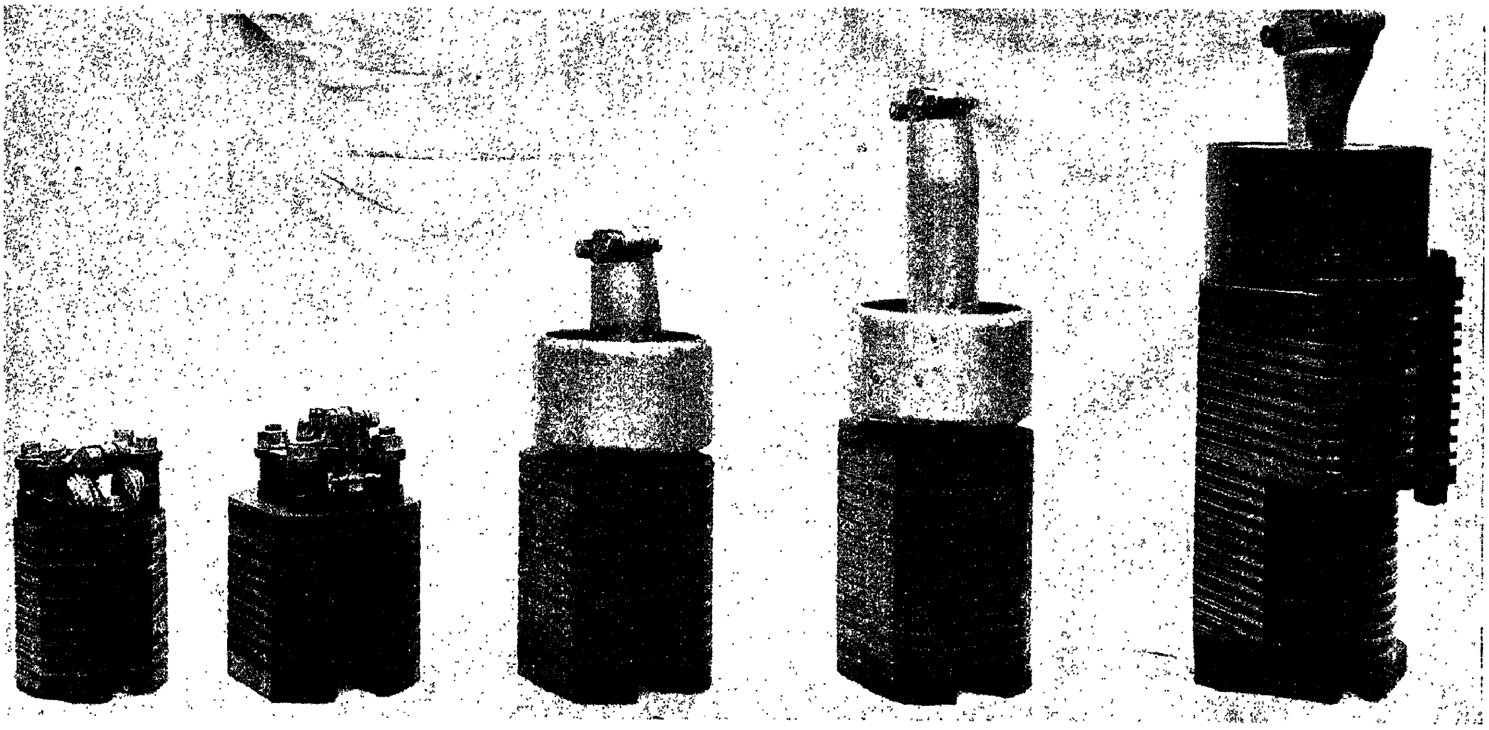


Fig. 6. Deion grid assemblies (from left to right) for installation in 34.5-46-kv., 69-92-kv., 115-kv., 138-kv., and 230-kv. oil circuit breakers

DEION GRIDS

A year ago this device was new and its preliminary development was reported.[13,14] At that time, practically no operating experience was available and results of certain important field tests were just being received. A broad commercial development of this idea has occurred in the past year and the deion grid may now be obtained as standard equipment for breakers of all voltages above 25 kv. and for interrupting capacities up to 2,500,000 arc kva.

The effect of powerful magnetic fields on the arc in oil breakers had been known for some time[1] and commercial apparatus for high-speed operation giving ½ cycle of arcing over a wide range of current from 2,000 amperes upwards at 12 kv. has been placed in service. Analysis of these results in the light of recent fundamental arc research showed that powerful deionizing action was at work. The blowout action of the magnetic field by extending the arc rapidly outward was maintaining it in intimate contact with fresh oil, and the gas generated by this contact between oil and the intense heat of the arc was unusually effective. This continual introduction of fresh un-ionized gas into the arc stream resulted in a high rate of deionization not possible by diffusion of ions into gases playing around the periphery of the arc. The arc path naturally regained sufficient dielectric strength to withstand restored voltage in a short time. This idea held hope of improvement in high-voltage breakers provided a proper physical application of the idea could be made. Ordinary blowout devices consisting of large coils and pole faces are not adapted for extremely high-voltage work, as the attendant problem of proper insulation is practically insoluble.

The use of oil in high-voltage breakers, however, presents a great advantage; the necessity for moving the arc terminals considerable distances from the original arc-drawing surfaces to scavenge the area between contacts did not exist. It was necessary only to develop means for utilizing the natural mobility of the arc and the inherent immobility of the oil while maintaining intimate contact between them, and to provide that the gas generated should pass effectively through the arc stream for deionizing purposes. This advantage was found in the deion grid, which provides a magnetic field to move the arc along a confined path as well as means for solidly entrapping the oil in this path with proper provision for gas escapement through the arc. Fig. 6 shows a number of these grids of various sizes suitable for a wide variety of operating voltages.

The introduction of the deion grid has been accompanied with intensive laboratory and field testing work, so that its performance has been carefully measured and its fundamental principles thoroughly understood. There is, therefore, assurance of satisfactory operation not procurable in the past, with novel devices for circuit interruption.

Performance of all sizes of deion grid is fairly comparable. For average circuits, 10 kv. can be opened per inch of break distance on a single break per pole and 20 kv. per inch of lift-rod movement on the conventional breaker having two breaks per pole. In the average case, arc energy is reduced to approximately 7 to 10 per cent of that obtained with usual open-break devices.

Conclusions

An analysis of circuit rupturing ideas now before the industry justifies the following conclusions:

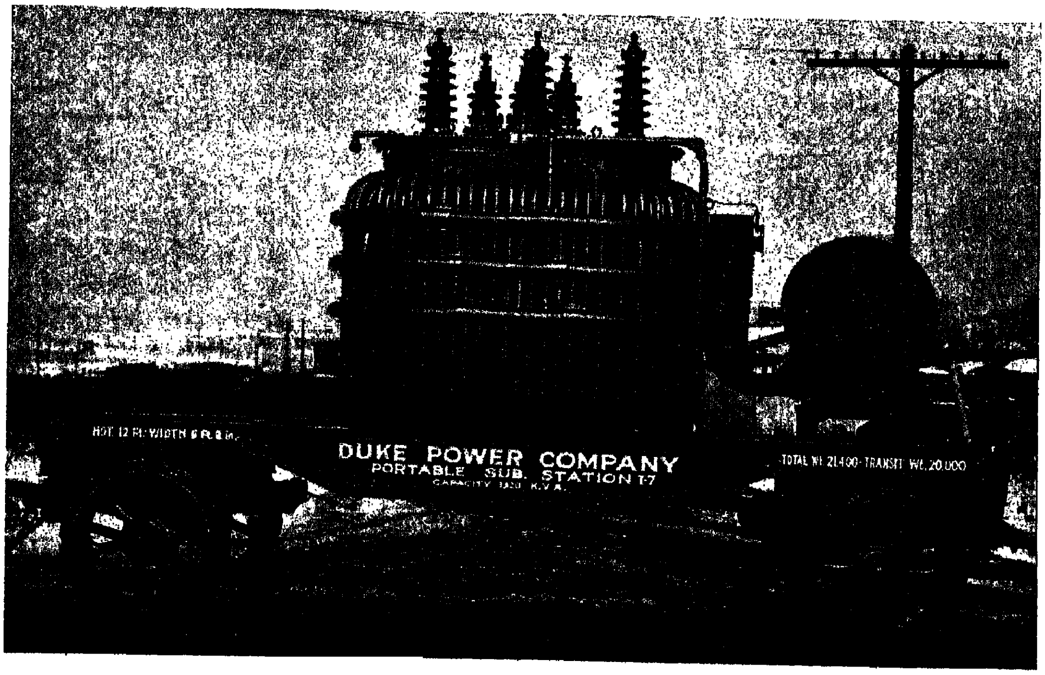
1. Several ingenious and rather well-developed devices which do not use oil as a rupturing medium are fast becoming available for commercial use.
2. All these devices, while possessing good arc-rupturing characteristics, are subject to the limitations of available insulating materials. Their application to high-voltage systems makes difficult the problem of coordinating the impulse values of lines and apparatus.
3. For reasons of insulation and difficulty of operation in unfavorable locations, conservative engineering would seem to limit the use of these non-oil-filled breakers to voltages of 25 kv. and below, and for the most part to indoor service.
4. Other things being equal, preference will naturally be extended to that form of non-oil circuit interrupter requiring no arc-rupturing medium, whether such medium be compressed gas, liquid, or vacuum.
5. Improvements have been made in oil circuit breaker design which assist system stability, reduce arc energy, and contact wear and breaker maintenance.
6. To secure coordination of apparatus and line insulation on large systems, the growing requirements for ample insulation factors on high-voltage circuit breakers, after, as well as before, rupturing duty has been performed, makes the use of oil in circuit interrupters extremely desirable for ratings above 25 kv., especially in outdoor service.

Bibliography

1. High-Speed Circuit Breakers for Railway Electrification, by H. M. Wilcox, A. I. E. E. Trans., Oct. 1926, p. 1285.
2. High-Speed Circuit Breaker in Railway Feeder Networks, by J. W. McNairy, A. I. E. E. Trans., 1926, Vol. 45, p. 926.
3. High-Power D-C. Tests, by H. M. Wilcox, *Electric Journal*, 1926, Vol. 23, p. 524.
4. Theory of Current Transference at the Cathode of an Arc, by J. Slepian, *Physical Review*, April, 1926, Vol. 27, p. 407.
5. Extinction of the A-C. Arc, by J. Slepian, A. I. E. E. Trans., Oct. 1928, p. 1398.
6. Theory of the Deion Circuit Breaker, by J. Slepian, A. I. E. E. Trans., April 1929, p. 523.
7. Structural Development of the Deion Circuit Breaker up to 15,000 Volts, by R. C. Dickinson and B. P. Baker, A. I. E. E. Trans., April 1929, p. 528.
8. Field Tests of the Deion Circuit Breaker, by B. G. Jamieson, A. I. E. E. Trans., April 1929, p. 535.
9. High-Power Circuit Breakers Without Oil, by J. Biermanns, *Elektrotechnische Zeitschrift*, 1929, Vol. 50, pp. 1073, 1114.
10. The Expansion Breaker, by F. Kesselring, *Elektrotechnische Zeitschrift*, April 13, 1930, Vol. 51, p. 499.
11. Vacuum Switching Experiments at California Institute of Technology, by R. W. Sorensen and H. E. Mendenhall, A. I. E. E. Trans., 1926, Vol. 45, p. 1102.
12. Temperature of a Contact, by J. Slepian, A. I. E. E. Journal, Oct. 1926, p. 930.
13. Extinction of the Long A-C. Arc, by J. Slepian, A. I. E. E. Trans., April, 1930, p. 421.
14. The Use of Oil in Arc Rupture, by B. P. Baker and H. M. Wilcox, A. I. E. E. Trans., April 1930, p. 431.

Portable Substation for Emergency Industrial Use

As an outgrowth of its railway-car portable substations the Duke Power Company, Charlotte, N. C., is using four of these 1,320-kva., 44-10/2.4 & 0.6-kv. trailer-mounted portables to back up the service of its 225 industrial substations. Total service weight is 21,400 lb., 1,400 lb. more than the legal highway limit, necessitating the withdrawal of five drums of oil before moving the equipment over a state highway —a condition, however, which expedites a necessary inspection of the terminal board and provides a load for the pulling truck thereby increasing its traction. The trailer may be handled from either end.


HGT. 12 Ft. WIDTH 8 Ft. 8 in.
DUKE POWER COMPANY
PORTABLE SUB. STATION 1-7
CAPACITY 1320 K.V.A.
TOTAL WT. 21400 - TRANSIT WT. 20,000

Current Collection in Hydrogen Atmosphere

Test runs of commutators and slip-rings operating in hydrogen gas reveal interesting characteristics and lead to five definite conclusions.

By R. M. Baker

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

THE FIRST electrical machine to be operated in hydrogen was the synchronous condenser, chosen largely because of the ease with which it could be covered by a gas-tight housing. Probably the next advance will be the application of a direct-connected exciter to one of these machines and that will require the exciter to be operated in hydrogen. If it is proved that commutation can be accomplished satisfactorily in hydrogen it may not be long before the hydrogen-cooled synchronous converter will make its appearance; therefore it would seem that much depends upon the accumulation of knowledge on the general subject of commutation and current collection in hydrogen. It represents a field which until just recently had received no attention. Whether or not there will arise any new and serious difficulties remains yet to be seen.

This paper is not intended as a complete treatise of the subject but only as a beginning. It describes a few tests made on commutator machines and slip-rings running in hydrogen which although not extensive establish a few facts quite conclusively.

Commutation Tests

Upon starting each new test it was necessary to pass considerable hydrogen through the tank to wash out the air, but after a good hydrogen purity was once established it was sufficient merely to maintain a small positive pressure in the tank.

Table I gives the results of five brush-life tests made on a short-circuited generator. All tests were made with full-load current in the brushes, but the generator was not always adjusted for the same grade of commutation. Tests Nos. 1, 2, 3 and 4 were made with 30 per cent of the current shunted from the commutating-pole winding of the generator. The sparking at the trailing edge of the brushes was quite severe and even under the most favorable conditions naturally resulted in rather short brush life. Test No. 5 was made with almost sparkless commutation.

TABLE I—CALCULATED BRUSH LIFE OF GENERATOR BRUSHES

Test No.	Duration of test—days	Atmosphere	Calculated brush life in days			
			Brush No. 1	Brush No. 2	Brush No. 3	Brush No. 4
1	15.0	Air	588.0	229.0	812.0	362.0
2	6.41	Hydrogen	94.4	9.2	128.0	10.6
3	6.78	“	222.0	205.0	282.0	161.0
4	7.0	“	43.7	59.9	69.3	45.0
5	15.0	“	1875.0	1770.0	2000.0	2310.0

Brush life is calculated on the assumption of one inch allowable brush wear. Brushes Nos. 2 and 4 are the two positive brushes of the generator and are on opposite brush arms.

The most interesting comparison is that between tests Nos. 1 and 2, which were made under identical conditions except that the former was made in air and the latter in hydrogen. In air the minimum calculated brush life was almost a year whereas in hydrogen it was only a little more than a week. Furthermore the damage to the commutator during the test in hydrogen was appreciable. The trailing edges of the commutator bars were burned away, in some cases as much as 1/32 in., leaving a bright metallic surface. This first test in hydrogen was quite unique in that it showed such a great difference in wear between the positive and negative brushes. Both tests described were made before a hygrometer was installed and consequently the relative humidity of the medium in which they were run is not known. It is very likely, however, that the test in hydrogen was started with a relative humidity of about 50 per cent and ended with a relative humidity of about 20 per cent.

Effect of Humidity

Tests Nos. 3 and 4 were made for the purpose of determining whether or not the unusually bad behavior of the brushes and the commutator in test No. 2 could be attributed to the high relative humidity which was suspected during this test. These tests were made with 30 per cent of the current shunted from the commutating-pole winding of the generator and the only difference in the two tests was in the relative humidity of the hydrogen atmosphere in which they were run. During test No. 3 the relative humidity was maintained at less than 10 per cent, whereas during test No. 4 the relative humidity was maintained practically constant at 50 per cent. Table I shows that the wear at the higher humidity was approximately four times as great as it was at the lower humidity. An inspection of the

---

From "Commutation and Current Collection in Hydrogen," (No. 31-36) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

commutator gave further evidence of improved performance during the low-humidity test.

Upon shutting down test No. 3 the commutator appeared dark and uniformly smutted, but apparently no damage had been done. A light application of fine sand paper showed the commutator to be in perfect condition. This however was not true of the commutator at the end of test No. 4. It was apparent immediately upon shutting down this test, that the commutator had been badly burned. The bright copper was showing on the trailing edge of the commutator bars just as it was after test No. 2, and the roughness could not be removed by any reasonable amount of sanding.

It is interesting to note that brushes Nos. 1 and 4 which were on the side of the machine nearest the moisture supply, showed somewhat shorter life than brushes Nos. 2 and 3 which were on the other side of the machine. In conclusion it may be said that if a commutator machine is running in hydrogen and sparking badly, the presence of moisture is detrimental to both the brushes and the commutator.

So far, all the tests described were made with the generator adjusted to give severe sparking at the brushes, the idea being to determine what would happen if this condition should arise in service. To show that operation in hydrogen may be quite satisfactory when commutating conditions are normal it only is necessary to refer to test No. 5, the results of which are tabulated in the last line of Table I. This test was made while the generator was delivering full-load current, but the shunt had been removed from the commutating-pole winding. The minimum brush life of almost five years and the good condition of the commutator at the end of this test would seem to indicate that as long as a machine is designed and adjusted for good commutation in air, it will behave quite satisfactorily in hydrogen. This last test was repeated several times and the same good results were always obtained.

SLIP-RING TESTS

The apparatus used in these tests consisted of a collector or set of slip-rings driven by an adjustable-speed d-c. motor and so arranged that the space around the rings and motor could be filled with hydrogen. Each ring was $\frac{7}{8}$ in. wide and $9\frac{1}{2}$ in. in diameter and was trimmed with one brush $\frac{5}{8}$ in. wide by $1\frac{3}{4}$ in. thick by 2 in. long. Direct current was supplied to the brushes and rings by an arc-welding set. Leads brought out through the bed-plate made it possible to measure the contact drop of any brush. Most of the tests were made with a current density of about 40 amperes per sq. in. and a peripheral ring speed of 2,500 ft. per min.

The first tests were made on a tool-steel ring trimmed with different grades of carbon and graphite brushes. The results of these tests were always the same. Lumps of hard material, sometimes 0.02 or 0.03 in. in diameter, were formed in the brush face and immediately began to score the ring. Upon analysis the hard material proved to be cementite (Fe_3C) which apparently had been formed by a direct combination of iron and carbon in the presence of localized high temperatures in the contact. In an attempt to prevent the formation of hard spots in the brush face, a helical groove was cut in the face of the tool-steel ring. With this change it was found that several brush grades which failed on the plain ring could be operated without difficulty; the formation of hard particles in the brush face was eliminated and the ring acquired a good polish.

These tests were quite similar to those made on the tool-steel ring and again the results were almost independent of the grade of brush used. When the air surrounding the rings was replaced by hydrogen all grades of carbon and graphite brushes showed a marked decrease in contact drop; in fact, the ratio of air to hydrogen was usually greater than ten to one. For most grades of brushes this reduction was permanent, although other grades after running for a while began to smut the ring; when this occurred the contact drop increased to about the same value as it would have in air.

No attempt will be made to explain the phenomenon disclosed by the above tests, but it was noticed that the results were peculiar to the particular brass ring on which the tests were made. Similar tests were made on the brass ring of another test set and it was impossible to even approach the low values of contact drop obtained in the first brass-ring tests. The only explanation which could be found for this disagreement in behaviour was the difference in the compositions of the two brass rings. This would also explain the fact that in the earlier tests the steel slip-ring showed only a slight decrease in contact drop when hydrogen was introduced.

CONCLUSIONS

It is realized that the tests reported in this paper are not very complete, but from the results of the tests described the following tentative conclusions may be drawn:

1. A commutator machine designed and adjusted for good commutation in air will operate satisfactorily and give good brush life in hydrogen.
2. If a commutator machine must spark in hydrogen the brush life may be increased many times by keeping the relative humidity below 10 per cent. This will also prevent damage to the commutator.
3. The contact resistance of carbon brushes on a commutator may be materially lowered by the introduction of hydrogen.
4. Carbon or graphite brushes cannot be operated satisfactorily on plain tool-steel slip-rings running in hydrogen.
5. The contact drop between a carbon or graphite brush and brass slip-ring may be ten times as high when th ring is running in air as when it is running in hydrogen.

Evolving a Modern Protective Relay System

The history of a decade of experience with various kinds of protective relay equipment on one of the nation's largest electric service systems is outlined here. Conclusions leading to, and methods of accomplishing, a complete revision in system operating practise are discussed.

By E. R. Stauffacher

Member, A. I. E. E.

Southern California Edison Company, Ltd.,
Los Angeles, California

PROTECTIVE RELAYS make possible a continuity of electric service under conditions which would have rendered such service impossible as little as ten years ago. Further, these sensitive devices permit improvements in transmission efficiency through enabling the safe use of lines in parallel with consequent reduction in $I^2 R$ loss, even though one line might have sufficient capacity to accommodate the load.

Previous to 1923 when the 150-kv. lines of the Southern California Edison Company, Ltd., were changed to 220-kv., no protective relays were employed. When a fault appeared the generator voltage was lowered and then gradually built up until the fault arc broke and ground currents ceased to flow. These faults resulted in service interruptions which could not be tolerated when the lines were changed over to the higher voltage. The decision was made therefore to install some form of relay protection. Phase relays of the induction type were so connected that two lines at a generating or substation were balanced against each other, both being under automatic protection. If it became necessary to remove one line of a pair from service, however, the other had to be made non-automatic, in which case the old scheme of reducing the generator voltage had to be relied upon. This plan while a great improvement over the older system of entirely non-automatic operation, was far from ideal, and the need for further improvement soon became apparent.

The first modification was in the form of balanced ground relays, similar to the phase relays already in service but designed to operate at lower-current values. This addition speeded up the clearing of heavy faults considerably, and provided further for the removal of faulty sections of line from the system when the ground current was too light to operate the phase relays.

With this combination of balanced phase and ground relays most faults were cleared without interruption to service; however, some interruptions still occurred when operating one line non-automatic, a practise still employed when one line of a balanced pair was out of service. Also, in a few cases when faults occurred during heavy-load periods the two ends of the system even after the fault had been cleared would sometimes drop out of step. This situation led to the installation of oscillographs and curve-drawing instruments several generating plants and substations to record transient conditions resulting from a fault. A study of records so obtained indicated a necessity for clearing the faults in a shorter time, limiting the ground current to as small a value as practicable, quick response of generator field excitation, and additional transmission line, only two 220-kv. lines then being in operation.

PROTECTIVE RELAY INSTALLATIONS—220-KV. SYSTEM

Table I shows the number of flashovers and other troubles on the 220-kv. transmission system from 1924 to June 1930. A study of the operating records from which this table was prepared demonstrated that at no time has there been any transient fault which has not been accompanied by a flow of some ground current. The wide spacing of conductors at this high voltage is responsible no doubt for the fact that the likelihood of phase-to-phase faults without a fault current to ground is rather remote. As a result of this situation, the practise of the past few years has been to abandon entirely the use of phase relays, depending solely upon ground or residual relays for protection.

TABLE I—220-KV. INTERRUPTIONS

Year	Number of faults	Faults cleared correctly	Number of times relays not in at time of fault	*System interruptions	Percentage system interruptions to faults
1924	22	8	13	14	63.8
1925	25	19	4	3	12
1926	36	27	1	8	22.2
1927	24	13	4	9	37.5
1928	26	18	5	7	27
1929	30	25	0	2	6.7
1930 Through June	20	18	0	0	0

*Due to load, severity of trouble, speed of clearance of trouble, location of trouble, system connections which determine source of power, and to protective relays being out of service.

Where two or more lines are connected to a generating plant or substation these lines are protected by induction, current-balanced relays connected in the residual connection of the bushing current transformers mounted

---

From "Development of a Relay Protective System" (**No. 30-191**), presented at the A. I. E. E. Pacific Coast convention, Portland, Ore., Sept. 2-5, 1930, and subsequently made available for publication.

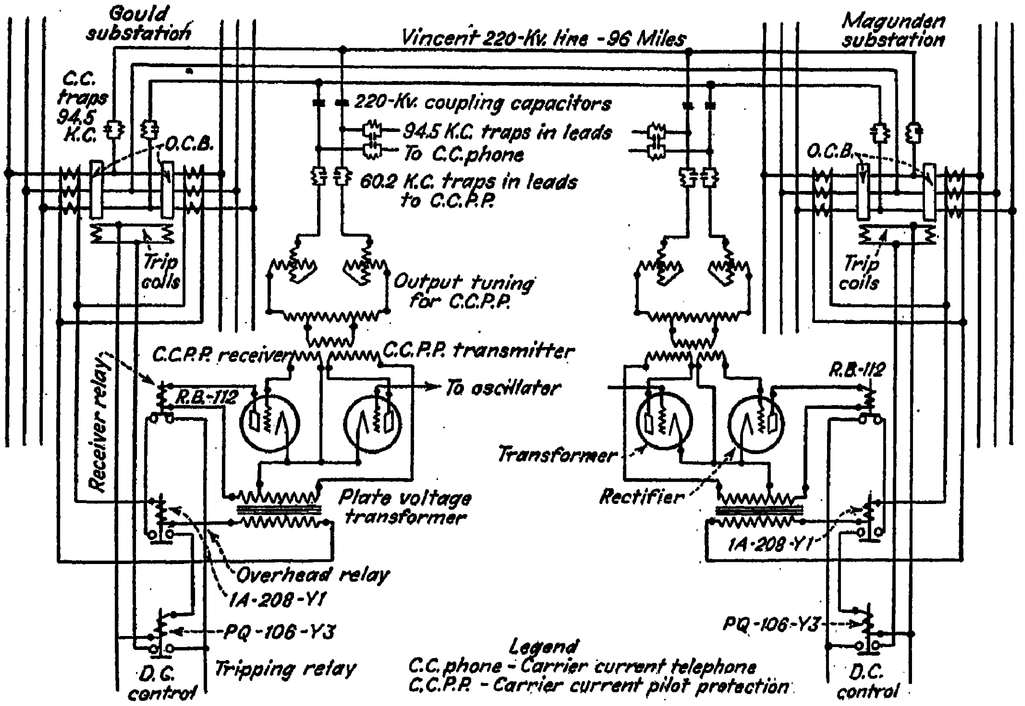
in the high-voltage oil circuit breakers. The relay scheme for single-line operation was changed to provide protection for a single line by means of residual directional relays actuated from the residual connection of the current transformers in the breakers and in the neutral or the residual connection of the station transformers.

The question of testing protective relays on important transmission lines has been a problem always, since to make an over-all test of the relays with the oil circuit breaker necessitated that a line be removed from service or be made non-automatic during the test. There have been a few cases of trouble when a section of line was operating non-automatic for relay testing. As a result it was decided to eliminate the possibility of an interruption from this source by installing duplicate sets of residual relays for each line, thus providing relays for each of the two oil circuit breakers controlling a line. This permits the testing of one set of relays with its oil circuit breaker, leaving the line under adequate protection with the remaining set of relays and oil circuit breaker. This latest scheme of protection completed in 1930 has been installed throughout the full length of the 220-kv. transmission system.

As a result of different routing and different substation connections, the company's third (Vincent) line between Los Angeles and the Big Creek plants has a current distribution somewhat different from the two other lines, and it has always been a problem to provide it with proper protection with the current-balanced relays which were satisfactory for the two original lines. The two terminals of one of the two sections of this line are switching stations not provided with any means of obtaining potential from the 220-kv. transmission line, and for this reason it was not possible to provide protection with power-directional relays. As a result of this condition, the carrier-current pilot protection was installed on the 96-mi. Gould-Magunden section of the 220-kv. Vincent transmission line and has been in service for nearly two years.

The carrier-current system is similar to the other forms of protection now in use on the 220-kv. system in that it provides for line-to-ground short-circuit protection only. It may be compared to the pilot-wire relay circuit, since the same net results are obtained. However, an exchange of relay-actuating current does not occur with the carrier system which operates instead to compare the direction of the two instantaneous residual currents at each end of the section of line affected. If the instantaneous residual current is in phase (in the same direction) indicating that a fault is external to the section protected, the equipment operates to lock out and prevent the induction overcurrent relays from tripping the oil circuit breakers. However, if the fault is in the section of line under carrier protection, current will flow towards the fault from the energy sources at each end of the section and the currents at the two ends will be approximately 180 deg. out of phase with each other. Under these conditions a fault within the section is indicated and the carrier-current receiver at each end is rendered automatically inoperative, permitting the induction overcurrent relays to function at both ends to clear that faulty section from the system.

Table II gives a summary of the results obtained with this protective equipment. When it is considered that the carrier-current system is an innovation in protective schemes, and that a great many problems had to be worked out before it was manufactured and installed, the results have been quite satisfactory. At each of



Schematic diagram indicating equipment and method involved in using carrier-current pilot protection system on a 96-mile section of 220-kv. transmission line

the two switching stations the section of the 220-kv. line so protected terminates in a set of two oil circuit breakers which connect to the two high-voltage buses at each station. Coupling between the 220-kv. Vincent line and the carrier-current pilot protection is obtained by means of oil-filled coupling capacitors connected to two of the three phase wires each connected from line to ground, giving what is termed "interphase" coupling. This coupling is made to the same phase wires at each end of the section protected, and the same set of capacitors is utilized for transmission of both the relay carrier frequency and the telephone carrier frequency over the same transmission line. Between the coupling capacitors and the 220-kv. oil circuit breakers at each station are installed carrier-current frequency traps built similar to a large choke coil and having a capacity of 800 amperes continuous duty with an inductance of approximately 70 microhenrys. Because of the double use of the capacitors, it is necessary to filter the protection carrier frequency and the communication carrier frequency into their proper channels.

TABLE II—SUMMARY OF OPERATION OF CARRIER-CURRENT PILOT PROTECTION ON A 96-MI. SECTION OF 220-KV. LINE

Total cases of trouble since carrier-current pilot protection installed..	28
Cases of trouble exterior to section..	20
Cases of trouble within section..	8
Correct operations..	26
Incorrect operations..	2

The relatively heavy volt-ampere burden placed upon the bushing current transformers by the carrier equipment and the necessity of exciting that equipment from the secondaries of these transformers requires that to operate the equipment the fault current be 320 amperes or more. This rather high setting has been satisfactory, but if practicable it would be desirable to obtain a setting of from 200 to 250 amperes. Studies and experiments by the manufacturers now are under way which give promise of obtaining certain characteristics permitting the lower setting to be used. The overcurrent induction-type relay which is used is designed to operate at unusually high speed. To obtain for the carrier protection the greatest speed of operation consistent with a reasonable life of vacuum tubes, the filaments of all tubes are operated at approximately full voltage, but with no excitation on the plates. Experience indicates a necessity for making a transmission check of the equipment at frequent intervals, and provision to do this every two weeks has been made.

66-Kv. System Protection

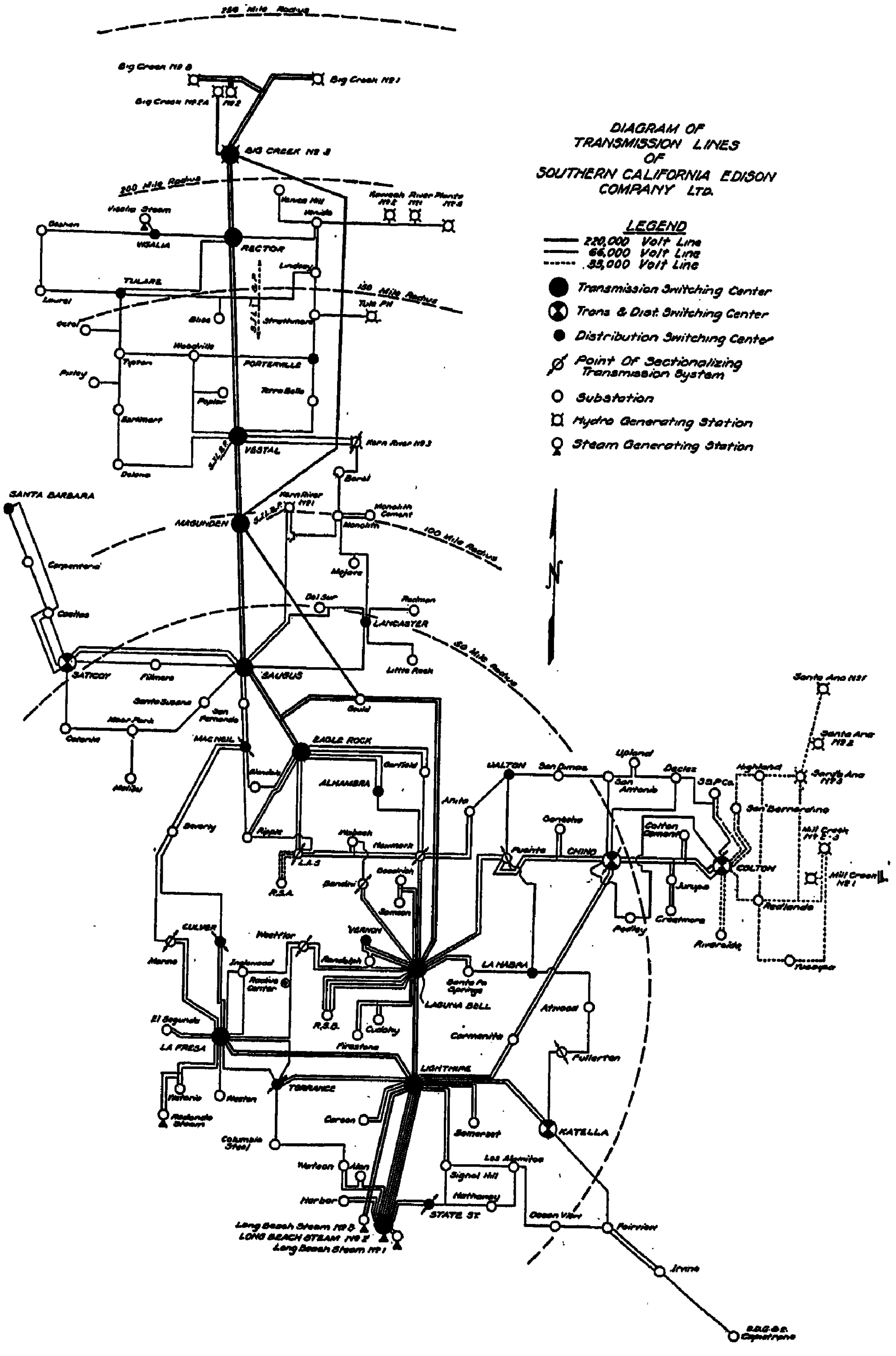
During the past few years the 66-kv. network of the Southern California Edison Company, Ltd., has been rearranged considerably particularly from the standpoint of routine operation and protection. Prior to some four years ago, the 220/66-kv. transmission receiving stations were interconnected quite closely on the 66-kv. side with the 66-kv. distribution stations looped into these connecting lines. The general practise was to have two or more incoming 66-kv. lines to each substation. Reliance was placed upon power directional relays to isolate faults, but because of the necessity of progressive timing for selective operation, the possibility of quickly isolating extremely heavy short circuits adjacent to the 220-kv. receiving stations became even more difficult. Accordingly in 1926 it was decided to begin changing the 66-kv. system from a loop to a radial system wherein each of the 66-kv. distribution stations would be supplied by two or more 66-kv. lines from one of the receiving stations. Furthermore, every effort was to be made to limit the phase-to-phase or phase-to-ground 66-kv. short-circuit current to approximately 1,000,000 kva. with an occasional exceptional upper limit of 1,500,000 kva.

With such a plan of operation it no longer was necessary to rely upon power-directional relays progressively timed; hence it was possible to take advantage of the characteristics of current-balanced relays wherein the currents in corresponding phases of two or more lines balanced against each other. This permitted a more prompt clearing of 66-kv. faults with consequent improvement in system operation. The decrease in the short-circuit current and particularly the increased speed of clearing short circuits due to the use of these relays has resulted in a marked decrease in a tendency towards system instability at the time of 66-kv. faults. As an adjunct to the line relays, current-balanced residual or ground relays when necessary have been installed and provision made to maintain protection by means of overcurrent or power-directional phase or residual relays for single-line protection.

16-Kv. and 11-Kv. System Protection

Heretofore the usual Edison method of providing for supply to 16-kv. or 11-kv. substations was by means of a separate feeder or a tap from a feeder radiating from a 66-kv. substation. During the past two years steps have been taken to provide two or more sources of supply to these lower-voltage substations, using either a scheme of loop operation between two 66-kv. substations or the preferred-and-emergency-supply method of operation. Recent analysis of the status of these lower-voltage substations supplied from the major 66-kv. stations shows that at present there are 35 distribution substations being operated on the loop system, of which 24 stations are operated on the 16-kv. system and eleven on the 11-kv. system.

A study of the cases of trouble experienced on lines supplying these stations shows that 38 cases of trouble were experienced during the first six months of 1930, and that 31 out of the 38 cases were cleared



Semi-geographic diagram of the transmission lines of the Southern California Edison Company, Ltd., showing the general plan of 66-kv. parallel-line supply to distributing stations adjacent to major receiving stations

correctly. In analyzing the seven cases which did not operate correctly it was found that two were caused by mechanical trouble in the oil circuit breakers, two by incorrect relay wiring, one by insufficient ground current, one by the d-c. trip circuit being de-energized, and one by unknown conditions. This record shows that there is room for improvement; however, results were so much more satisfactory than would have been experienced had the substations been supplied from a single radial line, as had been the practise in the past, that it is believed that loop operation of low-voltage distribution substations is successful and should prove a very efficient factor in minimizing service interruptions.

An analysis of experiences with the preferred-and-emergency scheme of operation shows that during the first six months of 1930 there were five cases in which the supply had to be changed over. In that period the only case of trouble experienced arose from a minor mechanical adjustment which caused one of the stations to fail to function properly.

Operating Experiences and Resulting Conclusions

For the past several years careful records of the performance of protective relays and automatic oil circuit breakers have been kept by the Edison company; Table III is a tabulated summary of 1929 experiences. It may be noted that the trend is towards fewer cases of trouble and consequently, generalizing, fewer automatic switch operations. There has been a decided decrease in unnecessary switch operations, which shows the result of wider application of protective relays with better knowledge of their characteristics and limitations. Intensive studies of the magnitude and distribution of phase-to-phase and phase-to-ground short-circuit currents have been of immense value in determining proper relay settings for various types and locations of faults.

TABLE III—OPERATION OF PROTECTIVE EQUIPMENT
220 Kv. to 11 Kv. Inclusive

	Year				
	1925	1926	1927	1928	1929
Cases of trouble	1493	2185	1799	1415	1303
Automatic switch operations	2368	3231	2831	2085	1923
Unnecessary switch operations	278	316	287	151	70
Failure of switches to operate	50	47	48	25	33

Decrease in "failure of switches to operate" has not been as marked, but these failures in general are the result of some form of trouble on the tripping side of the protective relays. A tripping coil may become defective, an auxiliary switch in the tripping circuit may not be making proper contact, mechanical faults may develop in the oil circuit breaker operating mechanism, or the control wiring may be defective.

A program of inspection, testing, and careful maintenance of the oil circuit breakers, protective relays, and tripping circuits is the only means of lessening these "failures to operate." Summing up in brief the results of operating experiences with the 9,300 protective relays now installed on the Southern California Edison system, the following conclusions seem warranted:

(1) In the interest of assuring a more reliable performance of the protective relays on the 220-kv. transmission system under conditions of testing and overhauling the protective equipment as well as during normal operating conditions, duplicate sets of relays are installed. This permits protection to be retained at all times.

(2) Use of carrier-current pilot protection on a 95-mi. section of 220-kv. transmission line has been satisfactory and has shown the value of this form of protection under conditions which would not permit the use of other forms of protective relays.

(3) Use of current-balanced relays and radial lines between the 220-kv. major receiving stations and the 66-kv. distribution stations has been an improvement over the previous practise of looping through the 66-kv. stations between adjacent 220-kv. stations. Elimination of the necessity of depending upon progressively-timed power-directional relays has speeded up the time required to clear faults.

(4) The practise of looping 16-kv. and 11-kv. distribution stations between adjacent 66-kv. stations in place of the previous practise of using single radial lines has resulted in a marked improvement in service.

(5) In rural districts the use of a remote alarm between unattended and attended stations to indicate when an oil circuit breaker trips out at the unattended stations has lessened the time of outage considerably. Private telephone lines or carrier-current equipment coupled to the transmission lines permits the installation of this remote alarm at a reasonable expenditure.

Allied Considerations

Successful application of protective relays on a transmission system is so closely linked with the static and transient stability of the system that whenever relays are involved consideration must be given to these characteristics. Stability is the limiting feature of long high-voltage transmission lines which determines the amount of power possible to handle commercially. It is obvious that the stability of a transmission system is determined by the longest section of line which may be isolated suddenly from the system to clear a fault. The static stability limit can be calculated readily to make it plain that if the power demand is such that the reduced transmission line capacity will not hold the generating and receiving ends of the line in synchronism, instability will result. Determination of the transient stability limit does not readily permit a definite solution since the factors to be considered cannot always be obtained with desirable accuracy. However, there is a number of outstanding features which can be considered and applied to a transmission system which will help greatly in maintaining stability under conditions of heavy short-circuit currents. Briefly stated these are:

1. Prompt clearing of faults is of prime importance in minimizing the loss of synchronism between the generating and receiving ends of a line.
2. A high short-circuit ratio (between 1.5 and 2) in generators and synchronous condensers aids materially in improving system stability.
3. Quick response or super-excitation for the fields of synchronous machines assists in maintaining transient stability.
4. The desirability of limiting ground currents so as to reduce the power demand on the transmission system at the time of faults is well established. This can be accomplished by installing current-limiting reactors in the transformer neutrals.
5. Momentarily decreasing the output of generators at the sending end of a long line at the time of faults reduces the likelihood of the two ends of the line dropping out of step.
6. A knowledge of the stability characteristics of the load supplied is helpful in making line stability calculations.
7. In studying relay problems or predicting inductive interference ground impedance along the line must be considered.

Bibliography

1. TRANSIENTS DUE TO SHORT CIRCUITS, by Wood, Hunt and Griscom, A. I. E. E. TRANS., Vol. 47, p. 68.
2. A CARRIER-CURRENT PILOT SYSTEM OF TRANSMISSION LINE PROTECTION, by A. S. Fitzgerald, A. I. E. E. TRANS., Vol. 47, p. 22.
3. CARRIER CURRENT REPLACES RELAY PILOT WIRE, by E. R. Stauffacher and F. S. Doolittle, *Electrical World*, Vol. 95, No. 12, p. 580.
4. EXTRA-HIGH-VOLTAGE TRANSMISSION WITH SPECIAL REFERENCE TO AMERICAN PRACTISE, by J. P. Jollyman and E. R. Stauffacher, World Power Conference, Tokyo, 1929, Paper No. 453.

Resistance Welding Improves Motor Frames

The ever present demand for cost reduction calls for continual revision of manufacturing methods. Motor frames as now made from rolled plate instead of castings as formerly used represent one such revision. Manufacturing methods are outlined here; oscillographic records reveal something of the character of a resistance flash weld.

By Malcolm Thomson
Associate A. I. E. E.

General Electric Company
Lynn, Mass.

ELECTRIC WELDING in its various phases has been the means of reducing the manufacturing costs of many industrial products. Three methods of welding are in common use today; namely, the carbon arc, the metallic arc, and the resistance methods. Of these three the resistance method has proved to be especially adapted to the welding of electric motor frames, having been used for this purpose since 1928. In this way motor frames can be fabricated from structural steel at a marked saving in cost as compared to corresponding cast-steel frames. In addition, these welded frames possess the distinct advantage of greater uniformity in both dimensions and structure.

Steel of the proper width and length for the rings, and with necessary allowance in length made for welding and sizing operations, is ordered from the mills in carload lots. That which has been found most suitable for magnet frames is a basic open-hearth-process steel of low carbon content. The slabs of the various sizes required for different sizes of magnet frames are unloaded at one end of the department; these are passed to a 1,200-ton hydraulic press which crimps or curls the ends to avoid flats and waste of stock at portions which cannot be rolled.

A view showing the steel as purchased and also illustrating the various steps in fabrication is given in Fig. 1. A typical ring in bending rolls is shown in Fig. 2. Attention is called to the vertical plate which insures accurate alinement of the ends of the ring during the rolling process. Electric motor drive is provided for raising and lowering rolls, as well as for the rolls themselves. The end section is pivoted and controlled by an air cylinder as shown in the figure, thus providing for quick removal of the rings.

From the rolls the rings pass by conveyer of considerable storage capacity, to a specially designed resistance flash welder of the Thomson-Gibb type. In Fig. 3 this welder is shown in action. The rings are held in place with powerful clamps actuated by hydraulic cylinders against special aluminum bronze die blocks. The operator first separates the ends of the rings slightly; then starts slowly feeding the jaws of the machine together with a hand-valve control of the hydraulic push-up cylinder.

Current is turned on by a push-button actuating a small contactor which in turn controls a large contactor, the latter closing the connection of the primary of the transformer to the power lines. As the ends of the ring meet, first a feeble, then a violent flashing occurs. A predetermined amount of metal is flashed off, averaging slightly less than an inch total. The abutting faces are brought to the melting point of the steel by the flashing process whereas the areas immediately behind are brought to a welding heat mainly by conduction, but partly by resistance. At the end of the flashing period, the full pressure of the hydraulic ram, which is about 100,000 lb., is applied, suddenly forcing the molten faces together. The result is a perfect and homogeneous weld, all burnt or oxidized metal being forced out. This welder while rated at 12 sq. in. cross-section maximum, is sometimes used on sections up to 18 sq. in. The welder has a 750-kv-a. water-cooled transformer with an open-circuit voltage of 12 at the welding jaws.

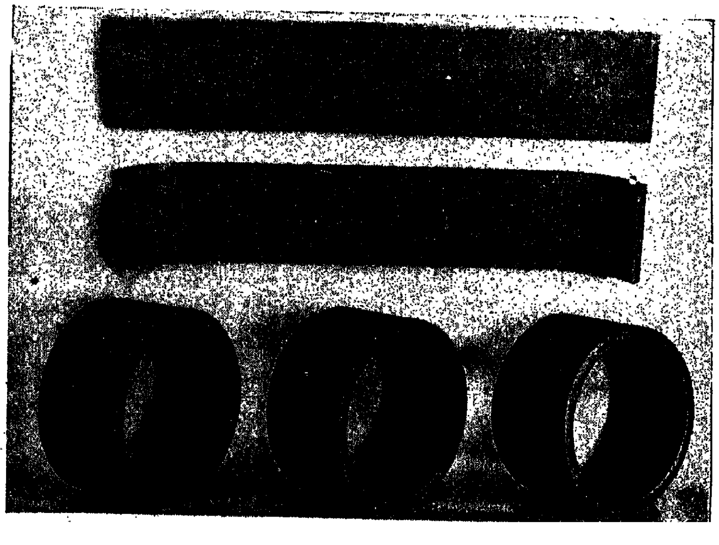


Fig. 1. Successive stages in fabrication of electric motor frame from structural steel slabs

---

From "Resistance Welding of Motor Frames," (No. 31-6) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

Due to the severe nature of the service, the demands on welding transformers require special features of design. The service is intermittent but large amounts of current are necessary, particularly at the final or upset period of the welding cycle. In order to facilitate repairs, accessibility is an important feature; hence the coils are usually assembled on a straight core section, a U-shaped section being then placed in position and fastened with bolts and straps to the straight section. On 60-cycle supply the core is worked at a flux density of from 60,000 to 80,000 lines per sq. in.

The secondary of this transformer consists of a single turn usually of cast copper with tubes for cooling water included in the casting. In larger transformers several cast-copper sections are often connected in parallel. The ends of the copper secondary are machined, one end being fastened solidly to the fixed platen. The other end is bolted to a flexible lead made up of many thin sections of copper strip, this lead being connected to the movable platen. The welding dies are located on top of the platens and are made of hard-rolled copper or special wear-resisting material, depending on the nature of the service for which they are intended. The work is very solidly clamped to these die blocks because of the push-up pressure required. The cast copper is worked at a current density of from 1,800 to 2,200 amperes per sq. in., the flexible leads at from 2,000 to 2,400 amperes and the joints at from 400 to 600 amperes per sq. in. The dies are worked at about 3,000 amperes per sq. in. current density. Wherever possible dies and platen as well as the transformer secondary are water-cooled internally and to avoid any unnecessary voltage drop the length of the secondary circuit is kept at a minimum.

Primary coils of the larger type transformers are usually built up of copper strip insulated between layers by a sleeve cloth or layer of asbestos paper. The coils are impregnated and baked; then wound with tape and finally painted.

Voltage regulation on the primary is obtained either by use of a separate auto-transformer or by bringing out taps to a regulating switch. Usually there are from five to ten points of voltage regulation, the lowest being about 50 per cent of the highest. Since on production work the breaking of the current may occur several times per minute, contactors used to switch on the power supply must be able to break full load of the welder without undue arcing or overheating.

Readings taken while welding a section of 18 sq. in. show that a primary current of about 900 amperes is required during the flashing period with a peak load of 2,250 amperes at the final or completion period of weld when the ring is forced together. The primary voltage at the time of these readings was 236, the transformer being supplied from a 60-cycle circuit. At high point

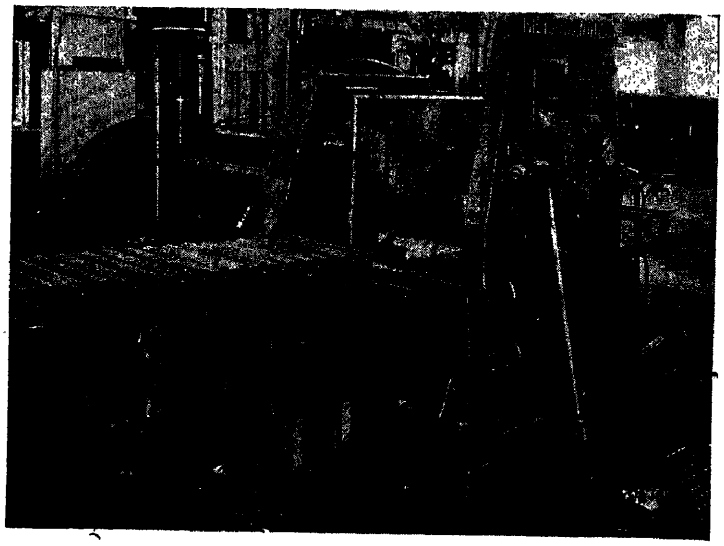


Fig. 2. Rolling machine for forming steel slabs into rings for motor frames

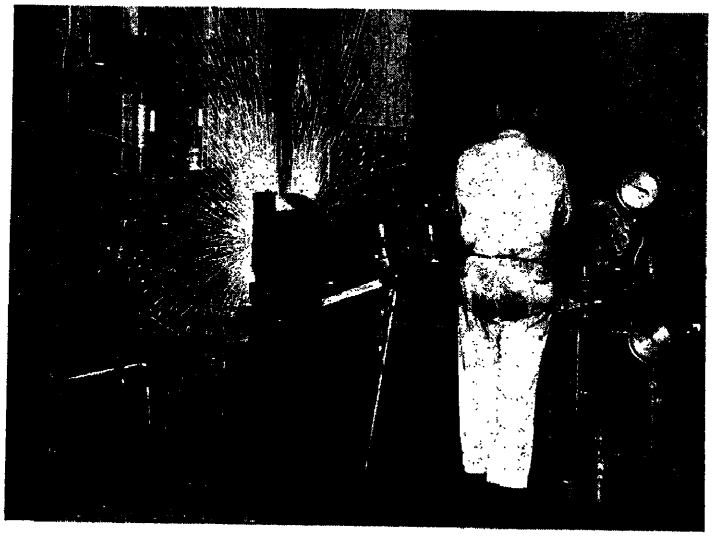


Fig. 3. A Thomson-Gibb resistance flash welder in operation. Magnetic field expels molten particles rather forcefully upward

Fig. 4. A hydraulic press for sizing welded frame rings

of weld, readings taken show a maximum of 461,250 volt-amperes and 252,000 watts power consumption, which gives a power factor of about 55 per cent. The average during flashing was 126,000 watts; power consumption with the secondary open, 1,400 watts.

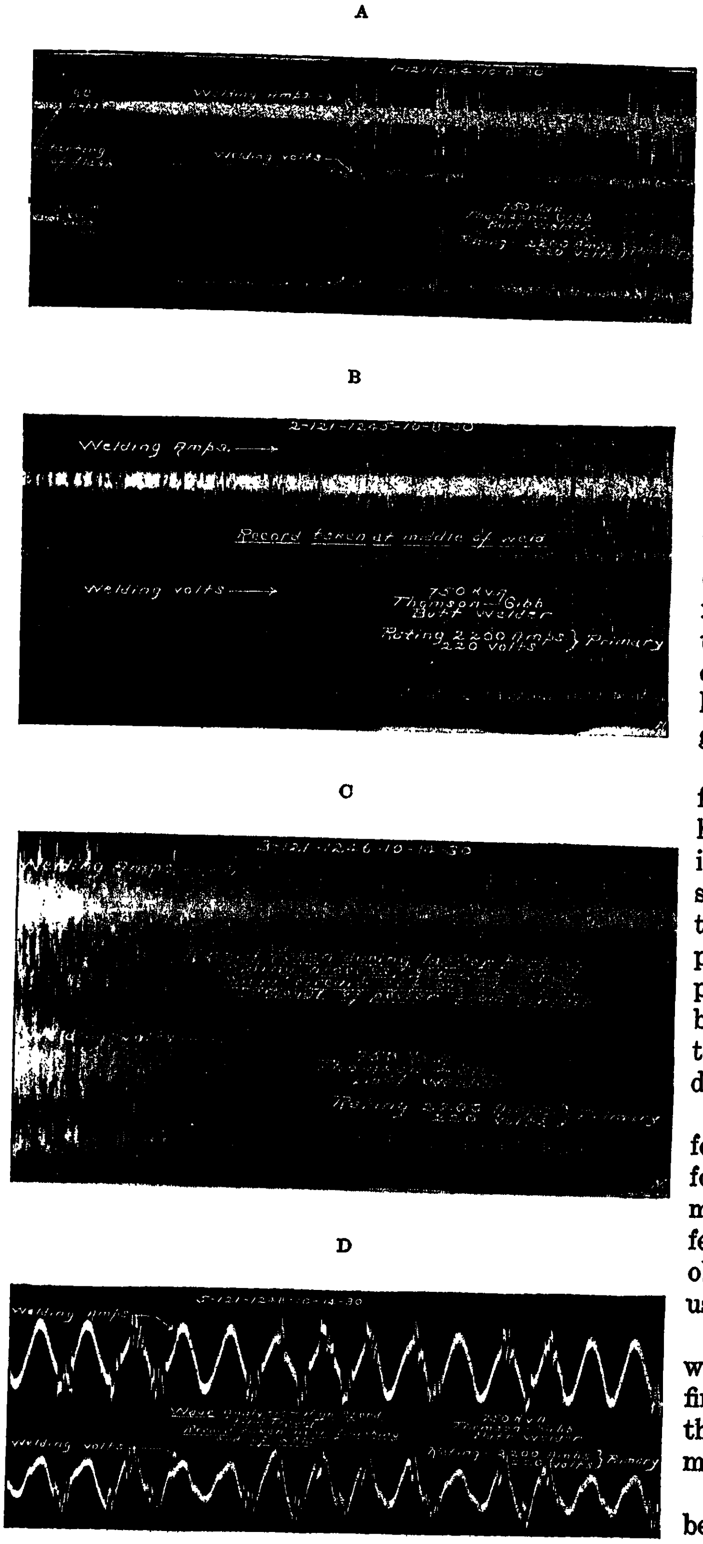


Fig. 5. Voltage and current relations at various stages in process of resistance weld. From top to bottom: beginning of flash period; middle of flash period; final stages; and wave analysis near close of flash period

Oscillograph records made on this welder are reproduced in Fig. 5. *"A"* shows conditions at start of flash, which consists first of a brief interval of short circuit, and then open circuit followed by beginning of contact of pieces. This represents a period of feeble flashing. As the flashing becomes more violent, conditions are as shown in *"B."* Toward the end of the flashing period, as shown in *"C"* when flashing appears continuous, the wave form still shows no continuous flow of current, but rather closely compact intervals of short circuit and open circuit. This picture also shows the upset or final push-up section of weld. A high-speed oscillogram made near the end of the flashing period is shown in *"D."* This illustration shows in some detail the intermittent nature of current during this period of the weld.

After the welding operation is completed, the ring is removed from the welder by an electric hoist. The upset resulting from the welding operation is removed by a vertical motor-driven broach which trims both the outside and inside of the ring while the metal is still red hot. The rings then pass by a conveyor similar to that previously mentioned, to an electric furnace. The electric furnace operation, while primarily used for heating rings for sizing, is advantageous also in that it gives the rings a strain anneal.

Rings are heated in this furnace to about 1400 deg. fahr. and then pass down a slide to an eight-cylinder hydraulic press located in the floor of the plant as shown in Fig. 6. (Part of the flooring has been removed to show the construction of the press.) It may be noted that in order to accommodate various sizes of rings this press is so built that each cylinder has a removable head portion. Rings are lowered horizontally into the press by means of an air-operated table and are then squeezed to within from 1/16 in. to 3/32 in. of correct size, depending on the size of the ring.

The frames are now complete with the exception of feet. The feet are made from steel bent into a "U" form in a hydraulic press, and are then cut apart by means of a gas torch. Each "U" makes one pair of feet and by inverting the "U's," right and left pairs are obtained. It is customary to cut all four feet at once using a double-torch machine for this purpose.

The sized rings pass by another conveyor to arc welding stations where the feet are tack-welded, then finish-welded into place. The completed frames are then sand-blasted, after which they are shipped to the motor building for machining and assembly.

By the use of electric welding of two kinds it has been possible to produce frames from 25 to 50 per cent cheaper than corresponding steel castings, with the added advantage of much greater uniformity in dimensions and structure. This, in turn, reflects a lowering of the machining costs and the production of better motors.

Low-Frequency Induction

The present status of joint development and research on low-frequency induction as it affects the closely associated circuits of the electric service and the communication utilities is outlined here.

By ***R. N. Conwell*** *and* ***H. S. Warren***

Associate A. I. E. E.
Public Service Elec. & Gas Co.
Newark, N. J.

Fellow A. I. E. E.
American Tel. & Tel. Co.
New York

INVESTIGATIONS being carried on by the Joint Subcommittee on Development and Research of the National Electric Light Association and the Bell System are in large measure concerned with induction at power-system fundamental frequency, its disturbing effects on communication systems, and remedial measures. This commonly-called low-frequency induction, has different characteristics and produces quite different effects from induction at noise frequencies as discussed in a companion paper by Messrs. Blackwell and Wills. Since very little has been published on low-frequency induction, it seems desirable to explain the problem in some detail in order to make clear what the joint subcommittee on development and research is doing on this subject.

Low-frequency inductive disturbances rarely occur under normal operation but are due usually to large unbalanced (residual) currents coincident with accidental faults in the power system. Although such abnormal conditions occur infrequently and usually last for only very short periods, the effects may be so serious that protection against this type of induction is an outstanding problem in the coordination of power and telephone systems.

Residual voltages and currents in effect are single-phase voltages and currents acting in a circuit consisting of the three line conductors in parallel as one side and the earth as the other side. Their large inductive effects are due to the great separation between the two sides of this earth return circuit, much of the return current being effectively so deep in the earth that its neutralizing action is small. The magnitude of these residuals is determined by (1) the power voltage and supply; (2) the impedances of lines, apparatus, earth, and fault; (3) configuration of conductors; and (4) characteristics of ground wires. Their frequency of occurrence depends upon the design and quality of construction employed, and upon the nature of external influences. Their duration is controlled by the effectiveness and speed of the relays and circuit breakers.

The magnitude of the voltages which these residuals induce into the communication circuits is principally determined by the location of the fault and magnitude of the residual current, the length of the exposure, the separation between power and communication lines, the location of ground connections on the two systems, and geological conditions affecting earth conductivity.

TYPICAL EXAMPLE

As illustrative of the effect of each of these factors, consider an exposure between a three-phase 26-kv. power line and a telephone line: The configuration of the conductors on the power line is an equilateral triangle, 30-in. spacing, conductors 250,000-cir. mil copper, height above the ground 40 ft., fault or residual current 1,000 amperes with the fault-to-ground at the end of the exposure. The exposure is five miles long with a uniform separation of 40 ft. between the power and telephone lines; height of the telephone line 25 ft. The assumed conductivity of the earth is 10^{-12} abmhos per cm. cube. Under these conditions, the induced voltage in the telephone line will be 1,870 volts. The effect of a change in the different factors on the induced voltage on the telephone line is as follows:

	CONDITION	INDUCED VOLTS
1.	Length of exposure doubled (10 miles)	3,740
2.	Residual current reduced to 500 amperes	935
3.	Residual current reduced to 200 amperes	374
4.	Separation increased to 60-ft.	1,700
5.	Separation increased to 3,000-ft.	34.5
6.	Earth conductivity 10^{-13} abmhos per cm.^{3} (40-ft. separation)	2,530
7.	Earth conductivity 10^{-14} abmhos per cm.^{3} (40-ft. separation)	3,200
8.	Earth conductivity 10^{-13} abmhos per cm.^{3} (3,000-ft. separation)	280
9.	Earth conductivity 10^{-14} abmhos per cm.^{3} (3,000-ft. separation)	792
10.	2/0-copper shield wire, grounded at both ends, installed on power line (zero ground resistance)	925
11.	2/0-copper shield wire grounded at both ends, installed on power line (5 ohms ground resistance)	1,370

Low-frequency and transient voltages induced on communication circuits may produce a variety of effects depending upon their magnitude and duration. These effects may include interruption of service, false signals, distortion of telegraph signals, damage to central office or other plant, acoustic shock, and electric shock.

Of the protective measures which reduce inductive influence, some are concerned with fundamental questions of power-system design; others with changes in circuit or grounding conditions, lines, equipment or operating methods. It is evident that protective measures to reduce the inductive influence of power

---

From "Status of Joint Development and Research on Low-Frequency Induction," (No. 31-23) presented at the A. I. E. E. winter convention as Part III of a symposium on coordination of power and telephone plant.

systems should be directed to limiting the magnitudes of the unbalance currents and voltages, particularly under abnormal conditions, and to reducing the duration and frequency of occurrence of abnormal conditions. Some of these protective features are preferably incorporated in the system when constructed as a result of cooperative advance planning, while others may be added later to care for effects due to subsequent developments in either the power or telephone system.

POWER SYSTEM PROTECTIVE MEASURES

Protective measures in the power system, which are available or under investigation for mitigating or eliminating these effects, are briefly described below.

Reduction in the frequency of occurrence of faults involves primarily the design and construction of the power line; that is, adequate insulation, clearance and spacings, and so arranging the component parts of the structure that the line will in effect be fault resistive. The principal elements which enter this problem are (a) design and spacing of conductors including ground wire so as to prevent arcing between them under expected conditions of sleet and wind loading, (b) proper mechanical strength of structures to withstand expected loading and (c) design and location of guys so as to provide adequate mechanical strength and at the same time make the minimum reduction in clearances and insulation.

The proper location of lines is a material factor in limiting the number of outages resulting from external sources, such as lightning, broken trees, blasting, and automobiles. The amount of insulation to be employed on lines should be governed by topographical and climatic conditions, and special attention should be given to areas where salt, fog, smoke, or chemical fumes are prevalent.

Resistors or reactors in the neutral ground connection of a power system provide a means of directly limiting the magnitude of the residual currents except in cases of double faults. In cases where without reacting unfavorably upon power system operation, the residual currents can be so far reduced as not to set up induced voltages of high values in the communication system this method alone may afford a satisfactory solution. In such cases it has the further advantage of reducing the stresses to the power system due to the fault current. Where it is impracticable to clear up a situation by residual-current limitation alone, this method may be effectively used in combination with other protective measures. Included in this work is a study of the relative advantages of inductance as compared with resistance for accomplishing such current limitation.

In non-grounded power systems a single fault on a phase conductor results in the charging current of the system flowing to earth through the fault. The other phases, rising to full-line voltage above the grounded phase, create a system unbalance which may manifest itself by induction in paralleling communication lines. In such cases the problem is one of electric induction except for the magnetic induction set up by the charging current.

Ground wires on a power line, while tending to increase the total residual current, serve the purpose of shielding by reducing the strength of the external electric and magnetic fields set up by the residual voltages and currents. The net effect of ground wires from the low-frequency standpoint is to reduce the voltages induced in paralleling communication circuits under abnormal power-circuit conditions. Such ground wires, if used on wood-pole lines, have a disadvantage in that they impair to some extent the insulating property of the poles.

High-speed breakers and relays are expensive and it is difficult to justify them solely as a remedial measure for induction, particularly as the speeds of operation now available for relays and breakers on power systems have not reached values which make them a complete solution of coordination problems. However, with the increasing size and interconnection of power systems, high-speed relays and circuit breakers are playing an increasingly important part in promoting power system stability.

The subcommittee is following the developments in high-speed breakers and relays with much interest; if such devices should come into general use for all classes of service it is expected that they will materially improve the whole inductive situation.

TELEPHONE SYSTEM PROTECTIVE MEASURES

In general, measures applicable to the communication system to prevent or reduce the effects of induced voltages take the form of arrangements or devices for removing or counteracting the voltages to ground or the currents in the telephone circuits which might be produced by induced voltages.

Protective measures in the communication system which are available or under investigation are briefly described as follows:

Bell System standard protective devices are intended to offer a measure of protection against lightning discharges and against the voltages and currents resulting from accidental contact with foreign wires, or from low-frequency induction.

In order to protect telephone linemen or others working on open-wire lines against electric shock from induced voltages, it is necessary that the voltages between line wires and between each line wire and ground be kept low. The use of protectors at central offices does not so protect the linemen as the impedance drop on the line wires permits high voltages between wires and ground at other points, such as the terminals of the exposed section.

In view of the inadequacy of existing forms of protectors for such use, the subcommittee is experimenting with a relay protector. This device includes Bell standard protectors in combination with a relay which operates to short-circuit them upon the occurrence of a discharge, thus relieving the protectors of the duty of carrying the large discharge current and greatly reducing their tendency to become permanently grounded.

The effective application of such protectors requires grounds of the order of one to two ohms, and an important feature of the investigation is to devise methods of constructing and maintaining such grounds at remote points along the line.

Since acoustic shock due to induced voltages involves dissymmetrical discharges across the two sides of the protector, efforts have been made to devise a protector which would break down and discharge symmetrically; *i. e.*, provide two reliable, low-impedance paths for heavy discharges which would at all times have very closely the same arcing impedance. Thus far the subcommittee has not been successful in developing a practical protector of this kind. In cases where toll or trunk lines are exposed, an acoustic-shock-reducing device which could be placed at the ends of the lines would have the advantage of protecting subscribers as well as operators. Development work to obviate certain difficulties in using such a device is under way and effort is being made to develop a telephone receiver which will saturate between the values of current required for effective speech transmission and values of current which produce acoustic shock. This requires a sharp bend in the saturation curve of the iron employed in the receiver magnetic circuit. Until the development of permalloy, this feature was not approachable, but experimental permalloy receivers have now been developed, and while it has not yet been possible to achieve the end sought without serious sacrifice in transmission, work along this line is continuing.

Drainage is a method for controlling the parts of the circuit in which the induced voltages appear, and causing these voltages to be consumed in parts where they are least harmful. This is accomplished by connecting the telephone conductors to ground (preferably through balanced impedance coils) at certain points throughout the exposure. Under present conditions, the application of drainage is limited to special situations where interference with circuit testing and maintenance is of relatively minor importance, and where superposed d-c. telegraph and carrier telephone are not used.

The neutralizing transformer is a device for introducing into an exposed communication wire a voltage in opposition to the voltage induced by the disturbing circuit, thereby to a certain extent neutralizing the latter. On account of introducing crosstalk, and adversely affecting telephone transmission and carrier, application of neutralizing transformers has been confined chiefly to telegraph circuits. They are being studied by the subcommittee to see whether or not the objections mentioned above can be overcome; also to determine their field of possible application.

Shielding on a telephone line may be effected by special grounded conductors, by working conductors or by cable sheaths. Miscellaneous structures such as pipe lines or rails in the immediate vicinity of an exposure also introduce more or less shielding. If the lead sheath of the cable is surrounded by magnetic material, as by armoring or placing cable in iron pipe, the shielding may be largely increased.

As bearing on the prevention of electric shock from induced voltages on telephone lines, shielding has a disadvantage, in that depending somewhat on the method of construction, it may add to the chance of a lineman making contact with grounded metal.

COORDINATED PROTECTION

Joint measures which may greatly obviate the ill effects of low-frequency induction are: Coordinated advance planning in order to effect the most advantageous location of new lines, and coordination of grounding practises to obtain separation of power and communication ground connections.

The ideal protective measure would be one which furnished adequate protection and had no unfavorable reaction from an economic or service standpoint on the system to which it is applied; however, the work thus far has not disclosed any measure which fully meets this ideal. The relative advantages of different protective measures differ in specific cases. The best solution for any case is the one which correctly balances technical results against over-all cost. Adequate separation of circuits is the most effective measure, but where this is not practicable, fault current limitation in the power system, and cable (particularly if shielded) for the communication circuits, afford the most generally effective protection (where applicable). In many situations, no single protective measure is adequate and two or more in combination are required.

As telephone circuits which are exposed to induced voltages may also be exposed to possible contact with power circuits and to lightning, any comprehensive scheme of protection must include consideration of the high currents resulting from contact and the high voltage due to lightning. The voltages produced by contact or lightning are somewhat similar in their effects to the voltages produced by induction, but differ in many important respects: Lightning requires protectors of a very high speed of operation, whereas contacts with power circuits necessitate protectors of high-current carrying capacity.

The program of work on low-frequency induction, undertaken by the Joint Subcommittee on Development and Research through its project committees, is laid out to develop the essential facts bearing on the problem of telephone protection in a broad sense, including causes, effects, and remedial measures. The program covers both the technical and the economic aspects of the problem.

Extensive field trials of the more promising protective measures are under way in order to determine their practicability under operating conditions. As the work progresses it is expected to issue from time to time reports covering the applicability, efficacy, limitations and conditions of use of various measures. This should result in a better understanding of the problem and more effective and economical solutions of specific situations as they arise.

A bibliography listing 32 of the more important writings on this subject which have come to the attention of the authors is given as a part of the winter convention paper of which the foregoing is an abstract.

◆ ◆ ◆

Noise-Frequency Induction

The present status of joint development and research on noise-frequency induction as it affects the closely associated circuits of the electric service and the communication utilities is outlined here.

By H. L. Wills *and* *O. B. Blackwell*

Associate A. I. E. E.
Georgia Power Company
Atlanta

Fellow A. I. E. E.
American Tel. & Tel. Co.
New York

OFTEN IT HAS been remarked that few problems are difficult to solve if all the facts bearing on them can be determined. The work of finding out the technical facts bearing on the problems of the physical relations of power and telephone circuits was intrusted to the Joint Subcommittee on Development and Research of the National Electric Light Association and the Bell System. This paper has to do with this fact-finding work so far as it concerns noise-frequency induction.

This joint subcommittee has subdivided its work among eleven project committees and has assigned to each the carrying on of specific research problems. It is not possible in the scope of this paper to discuss these various project committees and their work in detail; for the most part, results of the work of these project committees which have been published, or will be published in the future, must speak for them. The work on inductive coordination may be classified into three groups of factors:

1. Influence factors which concern the characteristics of the power circuits.
2. Susceptiveness factors, which concern the characteristics of the communication circuits.
3. Coupling factors, which concern the interrelation of power and communication circuits.

Before discussing these groups of factors it will be of interest to review the subject briefly from another point of view; namely, according to the methods which may be employed for the control of inductive interference. These methods are as follows:

Where two systems react unfavorably on each other, the first thought naturally is to keep them apart physically. In cases where the operating power and communication companies maintain close contact in their planning work, this may be a most effective method of handling coordination of important power-transmission lines and toll-telephone leads. With local distributing power and telephone systems, however, the need for serving the same customers requires that the systems be close neighbors. In connection with the matter of physical separation it should be noted that while a separation between lines of a few hundred feet practically eliminates the noise frequency problem, the low-frequency problem may exist with much greater separations. Where physical separation cannot be brought about, the methods of coordination employed must be along the lines of electrical separation. There are here three possibilities: Frequency separation, electrical balance, and shielding.

The idea of electrical separation by use of different frequencies is familiar to nearly every one today because of the development of radio broadcasting. It is happily true that the frequencies used for power transmission are comparatively low, and the frequencies necessary for good speech transmission are ordinarily well above this range. The figure shows a diagram of the various uses of the frequency spectrum for electrical transmission, and the manner in which power and telephone services are coordinated by frequency separation.

An important part of this matter of frequency separation is evidently the question of wave shape in the power systems and the relative amounts of power employed in the two systems. While the amounts of power at harmonics of the fundamental frequency in power circuits are negligible in comparison with the total power transmitted, they are large compared with the

---

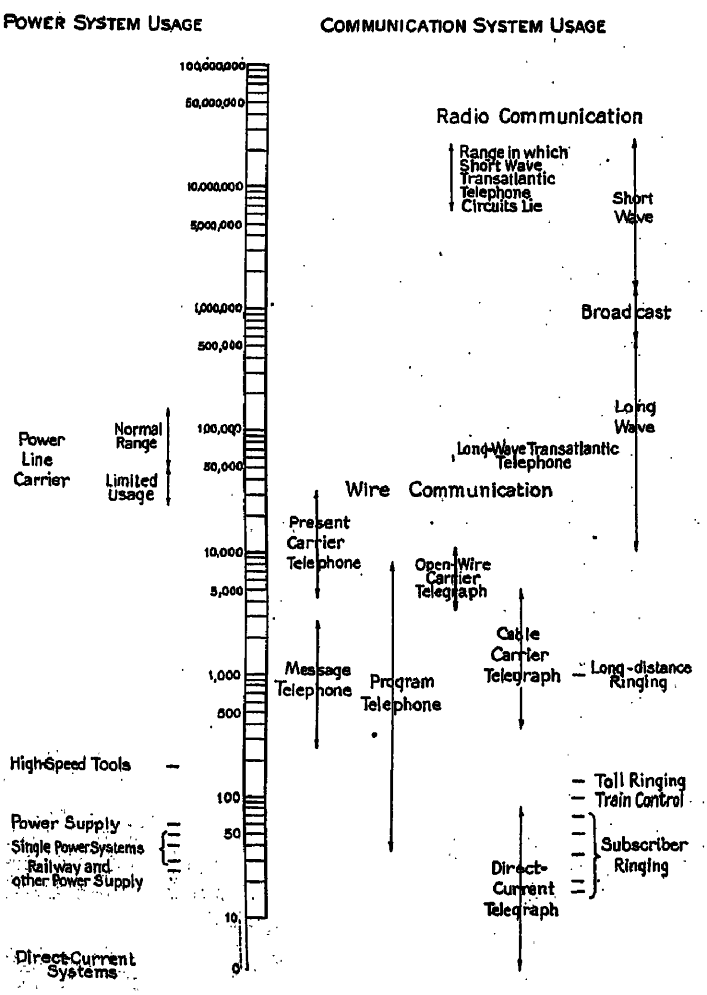
From "Status of Joint Development and Research on Noise-Frequency Induction," (No. 31-22) presented at the A. I. E. E. winter convention Part II of a symposium on coordination of power and telephone plant.

power employed in the telephone circuits, and fall directly within the frequency range used for telephone transmission. On the other hand, while the powers involved in telephone transmission are small compared with those on power lines, they are, in turn, large as compared with the acoustic power received from the talker or delivered to the listener.

Electrical balance is another fundamental means of bringing about electrical separation. A perfectly balanced power circuit could not influence an adjacent communication circuit; nor could a perfectly balanced communication circuit be interfered with by a power circuit. Perfect balance, however, is a virtue which is difficult to obtain, and the problems of balance in electrical circuits present some of the most interesting and difficult technical questions being considered.

Shielding is a third possible method of electrically separating two systems. The different wires of a telephone line have an important shielding effect on each other. The most important practical phase of shielding is the use of lead sheaths on telephone cables which have a most important effect in practically eliminating electric induction in the cables. The method is limited, however, by the difficulty of bringing about a comparable degree of magnetic shielding.

FREQUENCIES USED FOR ELECTRICAL TRANSMISSION



Returning to the method of analyzing inductive coordination into influence, susceptiveness, and coupling factors, the important influence factors of power circuits are wave shape and unbalance on the operating voltages and currents. Wave shape is determined by the characteristics of the apparatus associated with the system; and balance is determined by the degree of symmetry of the generated voltages and of the apparatus load and line impedances. In order to obtain a broad picture of the wave-shape conditions that exist in the field of operating power systems equipped with various types of apparatus, an extensive survey was made including measurements on 34 operating power systems in the eastern half of the country. The program was arranged to obtain information as to the average and range of magnitudes of harmonics present in various types of transmission and distribution systems under normal operating conditions; to observe the relation between the wave shape of generating machinery under open-circuit conditions and under load; to study effects of various transformer connections on wave shape, and to observe the effects of various types and magnitudes of load. The data accumulated are being summarized in technical reports which will be published upon their completion.

The important sources of unbalance in power circuits are (1) triple-harmonic residual voltages and currents arising with rotating machinery or transformers connected in star with neutral grounded; (2) differences in the loads connected between the phase wires and neutral of three-phase four-wire distribution systems; and (3) differences in conductor capacitances-to-ground due to single-phase branches on three-phase systems.

Experience has indicated that the outstanding factor is the existence of the triple-harmonic residual voltages and currents. A large measure of control may be exercised on the magnitudes of the triple harmonics by the use of certain transformer connections and by avoiding the operation of transformers at high flux densities.

A technical report has been published dealing with noise-frequency induction which arises when star-connected generators operating with grounded neutrals are connected directly or through star-star transformer banks to transmission or distribution systems. Information is given on methods of reducing the influence under such conditions.

A laboratory study of transformer harmonics and transformer connections is under way; this is to be supplemented by tests on large transformers in the manufacturers' shops and in the field.

The important susceptiveness factors of telephone circuits are unbalance, sensitivity of the receiving apparatus, and operating power level of telephone circuits.

Unbalances in toll circuits are the result of commercial variation from the balanced condition, the circuits being designed to be symmetrical. These unbalances include resistances in joints, transposition irregularities, and differences in the impedances of shunt or series apparatus.

Because of the shielding effect of the telephone cable sheath, the high degree of balance of the terminal apparatus and the more general use of private rights-of-way, cases of noise-frequency induction into toll-cable circuits are comparatively infrequent.

Certain unbalances exist in exchange circuits due to the arrangements used for selective ringing, for coin box service, and for supervisory signaling. These unbalances have been investigated in detail and the results published in a technical report. Party-line unbalance due to the ringer ground is usually the controlling unbalance, so that coordination difficulties between telephone exchange systems and power distribution systems usually involve the party-line circuits before individual line circuits are affected.

The coupling between power and telephone circuits for a given degree of proximity depends upon the balance of the two classes of circuits to each other and ground. Advance has been made in methods for predetermining the coupling in new cases of exposure and for reducing the coupling in given situations of proximity. Extensive studies have been made of coupling of power-distribution circuits and telephone-exchange cable circuits using the same pole lines; the results have been published in technical reports. Much work has been done also on the coupling of open-wire telephone circuits both with power-distribution and power-transmission circuits; the results will be published as soon as they have been prepared in suitable form.

Coordinated transpositions of open-wire power and telephone circuits are a powerful tool for controlling this coupling. Available information is inadequate, however, as to the effectiveness of transposition in situations where important line irregularities occur which it is not possible to take into account in the transposition design. The subcommittee is investigating this problem.

Many of the existing noise-frequency induction problems have arisen because of the development of the art of the two industries without such close cooperation between them as now exists. From the work of this joint subcommittee it is becoming evident that while it is not practicable to design machinery and apparatus for power systems to be entirely free of harmonics, or to ideally balance either power or telephone circuits, it is possible to control these factors within limits which, in conjunction with the control of coupling obtainable by cooperative planning of routes and coordination of transpositions, permit satisfactory operation of both services without unduly burdening either.

A bibliography listing seventeen of the more important writings on this subject which have come to the attention of the authors is given as part of the winter convention of which the foregoing is an abstract.

Interference in Ocean Cable Telegraphy

The character of interference which may be present near the ends of submarine telegraph cables depends upon many local factors and can be determined only by actual field measurements. Relations between this interference and cable operation are discussed.

By J. W. Milnor

Fellow A. I. E. E.

Western Union Telegraph Co.
New York

PERFORMANCE of many submarine telegraph cables is affected by extraneous electrical interference. Often the message capacity is definitely limited by this factor. Consequently, it is desirable that the relations between interference and the performance of cables be studied and methods for measuring interference be developed and standardized.

The most common interference is of natural origin—from the same sources which cause the atmospheric disturbances or static which affect radio systems. Sometimes there is also interference caused by other cables or by electric railway or power systems. The amount of interference due to natural causes varies widely in different cables, being affected by the depth of the cable, the design of the core and the sheathing, the nature of the sea bottom, and other conditions. In general, the amount can be predicted only from measurements made in the vicinity.

Influence of interference upon the operation of cables is first discussed under the assumption that the interference is sinusoidal; this is then extended to include the actual interference which is quite irregular in form. Since the computations with non-sinusoidal interference are too tedious for general field use, an experimental method of measurement is given which may be used directly in determinations of the effects upon cable operation.

Interference and Cable Performance

If alternating current is transmitted into a cable and sinusoidal interference of approximately the same frequency is present at the opposite end, the relative

---

From "Submarine Cable Telegraphy: Influence of Interference," (No. 31-8) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1930.

deflections of the receiving instrument due to these two sources may be computed readily from the known characteristics of the cable. The deflections due to sinusoidal interference of other frequencies and to various combinations of telegraph characters received through the cable also may be computed; but for this purpose it is necessary to know the manner in which the receiving equipment responds to sine-wave voltages of various frequencies. Such a frequency characteristic may be computed from theory or determined experimentally. For satisfactory operation it appears necessary that the deflection due to telegraphic characters should be at least five times the deflection caused by interference. Ordinarily the interference in a cable is not sinusoidal. An example of its irregular form is given in Fig. 1.

Knowing the frequency characteristic of the equipment, it is practicable to determine its response to various simple forms of transient induced voltage such as might be caused by interference. The computation is straightforward and involves a single, definite integration ("Submarine Cable Telegraphy," A. I. E E. TRANS., 1922, p. 200); a number of examples have been worked out. It is also possible to compute the effect on signal reception of actual interference such as shown in Fig. 1; however, in that case the computations are too tedious for use in general studies of interference. Such computations are made unnecessary by the experimental method of investigation about to be described.

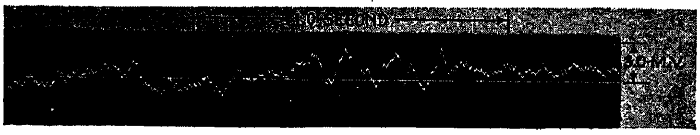


Fig. 1. Record of cable interference obtained using distortionless amplifier

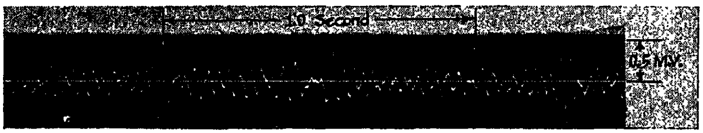


Fig. 2. Record of cable interference with amplifier tuned to 30 cycles per second; decrement = 0.8

FIELD MEASUREMENTS

Obviously the most accurate method for determining the practical effect of interference would be to obtain records using receiving equipment which is adjusted to give properly shaped signals on the given cable. This method is not always convenient and has certain other objections.

An examination of the frequency characteristic of efficient receiving equipment indicates that it is somewhat similar in general form to that of a simple electrically-tuned circuit, and the method therefore suggests itself of making use of such tuning while the field records are being obtained. Since the quantity to be measured is highly erratic in amount such a method has been found to be sufficiently accurate for the purpose. The frequency of the tuned circuit must correspond to that frequency at which the cable equipment is most sensitive, and the broadness of tuning should approximate that of the equipment.

A convenient arrangement of apparatus for the purpose is an oscillograph connected to the output of a vacuum-tube amplifier, the latter having a symmetrically-tuned circuit between two of the stages and being otherwise distortionless. The tuning may be provided by means of a low-loss inductor and condenser and resistor in parallel, this combination constituting the external-plate load of the preceding tube. The resistor controls the broadness of tuning, the broadness being conveniently specified by stating its logarithmic decrement. The highest peak on the oscillogram is recorded as the amount of interference under the given conditions.

A sample record obtained with such equipment is shown in Fig. 2; an example of the manner in which the peak interference varies with the tuning frequency is given in Fig. 3. The measured interference also varies with the decrement and with the length of the record. The resulting effects on cable behavior may be determined with the aid of the above discussion on the influence of sinusoidal interference.

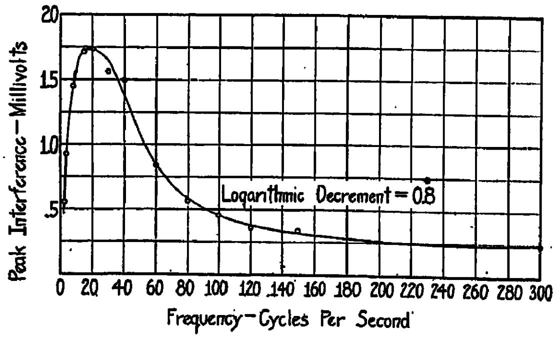


Fig. 3. Variation of peak interference with frequency of tuned circuit

IMPULSE RESPONSE CURVES

By means of a simple experiment it is possible to determine directly what may be termed an impulse characteristic of the receiving equipment associated with a cable. This characteristic as here used is defined as the transient response of the receiving instrument, when an instantaneous or pure impulse of voltage is impressed in series (across a small resistor) in between the cable and its receiving equipment. It is interesting to note that when the other is known either the frequency characteristic or the impulse characteristic may be computed by means of an integration. In order to determine the impulse characteristic experimentally, a charged condenser of proper size may be discharged across the resistor. An examination of such a characteristic yields valuable information as to the approximate frequency at which the equipment is tuned, and also gives an indication as to the sharpness of tuning and the sensitiveness.

◆ ◆ ◆

Transforming Reactor Improves D-C. Arc Welding

Transients normally prone to occur in a welding generator are eliminated by compensating action of a simple device external to the generator; desirable external reactance also is provided for a welding circuit.

By S. R. Bergman
Associate A. I. E. E.
General Electric Company
West Lynn, Mass.

ARC WELDING, particularly when applied to ferrous metals has developed during the last decade into an art of great importance in industry. As this art progressed, the requirements for a proper power supply has been studied with the view of obtaining uniform and great strength of welds as well as ease in welding. To meet this demand, a motor-generator set has been developed and in addition, an auxiliary device of inductive character to aid the generator in producing ideal welding conditions.

Requirements for the generator may be stated briefly as follows:

1. The open-circuit voltage was chosen to range from 70 to 90 volts because experiments had shown that it is desirable to have this voltage above 70. With less voltage available, the arc has a tendency to break as it is elongated by unsteady welding or by the blowing from influences of external magnetic fields. This voltage is required also to break through scale on the iron. Tests have shown also that there is no advantage derived from a voltage higher than 80, although a margin of 10 volts above this to compensate for the voltage drop in long leads is advantageous.

2. The arc voltage runs from 14 to 25 depending upon the strength of the welding current. Thus it is required that the voltage of the generator should drop inherently from an open-circuit voltage of 70 or 80 to an arc voltage of 14 to 25. Regulation of the generator, as shown in Fig. 1, gives approximately a straight-line relation between voltage and current.

As illustrated in Fig. 2, the generator principle involved is that of a dual magnetic circuit. The armature is wound for two poles and the field contains four poles; in general, the armature should be wound for half the number of poles contained in the field. In d-c. machines of standard design adjacent poles have opposite polarity, but in this machine the poles are paired in groups of the same polarity (a group of two north poles followed by a group of two south poles).

To establish a working theory, assume that the flux distribution is as in Fig. 2. There exist two fluxes ϕ_m and ϕ_c displaced 90 electrical deg. from each other. The flux ϕ_m will be designated the main flux, and the flux ϕ_c, the cross-flux.

Load current of the armature is taken from the two brushes, *A* and *B*, placed at neutral points between poles of opposite polarity. In addition there is an exciting brush, *E*. This machine is self-excited, the excitation being taken from brushes *A* and *E* in Fig. 2. The main magnetic circuit is so designed that magnetic saturation exists, whereas the cross-magnetic circuit is designed without saturation. As soon as the armature is loaded there is set up an armature reaction *R*, which may be resolved into two components *R M* in the direction of the main flux and *R C* in opposition to the cross-flux. Since the main magnetic circuit is saturated, component *R M* cannot force any more flux through this circuit and the main flux remains practically constant. Component *R C*, however, blows out the cross-flux which thus decreases as the load increases. Machine voltage *A B* is the algebraic sum of *A E* and *E B*. Voltage *A E* is induced by the main flux and remains practically constant since the main flux and the speed are constant. Voltage *E B*, however, decreases with the load since the cross-flux decreases as

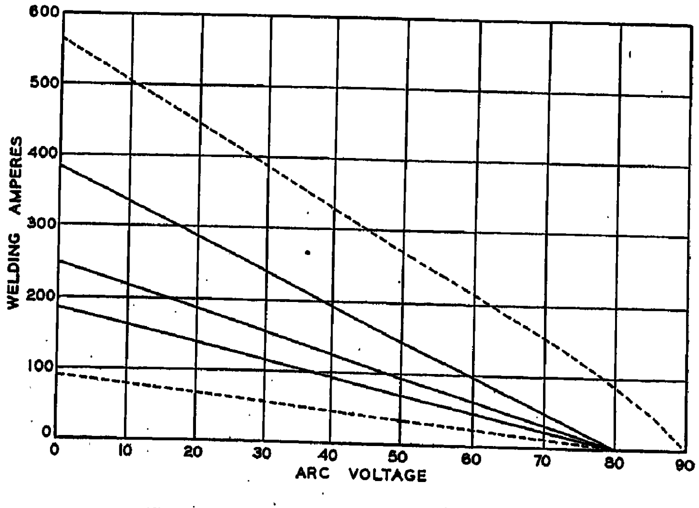


Fig. 1. Generator characteristics

From "A New System for D-C. Arc Welding," (No. 31-19) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

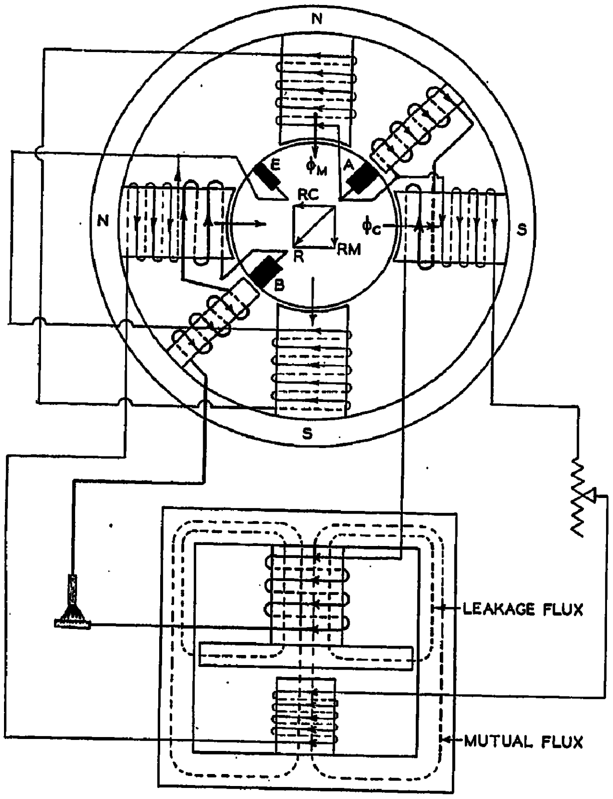


Fig. 2. Schematic diagram showing principles of generator and method of connecting transforming reactor

described. As a matter of fact, the cross-flux passes through zero and is finally reversed.

If it is desired to weld with smaller currents, a series winding is placed on the cross-poles supporting the armature reaction. It being desirable to obtain different welding currents, the series winding is provided with taps; and to secure close adjustment of the welding current a field rheostat is inserted in the cross-circuit. To obtain good commutation, commutating poles are added.

This design results in a set of welding currents as shown in Fig. 1 which particular curves apply to a machine rated at 300 amperes and capable of delivering a minimum of 75 amperes, and a maximum of 450 amperes.

In actual welding the current is never constant because the circuit frequently is short-circuited by small globules of metal and because the electrode is not fed at exactly the proper rate, particularly in hand welding. Under such conditions, transient currents and potentials appear in the generator and the regulation deviates from the curves shown in Fig. 1, which correspond to static conditions. In striking the arc, the current overshoots its steady value, and in breaking the arc a certain time interval is required for the voltage to return to its normal open-circuit value. It is desirable that the short-circuited current should not be excessive, and it is also desirable to have the voltage build up rapidly.

To cope with these transient conditions, a special inductive device which may be called a transforming reactor was developed. (Fig. 2) The primary winding of this device is connected in series with the arc, and its secondary winding in series with the shunt field of the cross-magnetic circuit. These two windings are connected in such a way that the direct current flowing through them will magnetize in the same direction.

The function of the transforming reactor is to provide external to the generator a magnetic coupling between the arc circuit and the field circuit, which coupling will be opposite in effect to that between the two circuits within the generator. Suppose that the arc is suddenly broken; then the ampere-turns of the arc circuit (both in the generator and in the transforming reactor) suddenly disappear and since the secondary winding attempts to maintain the mutual flux, the secondary current has a tendency to increase and counteract the tendency of the generator magnetic circuit to make it decrease. Thus the transforming reactor tends to keep the cross-shunt field current constant regardless of changes in the arc-current. The result of this is to make the voltage build up more rapidly to its normal value when the arc is broken, and to limit the peak value of current when a short-circuit is made.

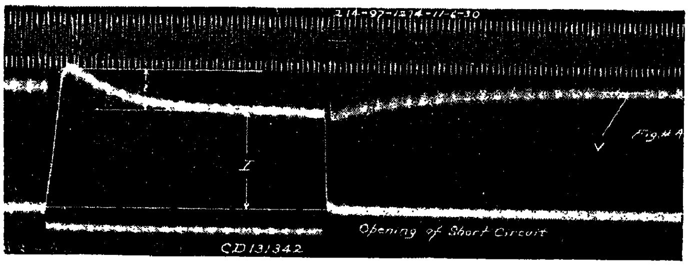


Fig. 3. Oscillographic record of action of combination of Fig. 2 under conditions of suddenly-applied and suddenly-relieved short circuit

To illustrate the principle of this generator in conjunction with the transforming reactor an oscillogram is shown in Fig. 3, showing what happens when the arc is short-circuited and the short circuit immediately thereupon opened is given in Fig. 3. The steady value of the short-circuited current is I, and the transient value i is quite small. When the short circuit is removed, it may be noted that the generator voltage builds up to the open-circuit voltage, V, almost instantaneously.

This oscillogram proves that the transforming reactor fulfills its purpose in practically eliminating the transients, making the generator, during sudden changes of arc current, follow the regulation curves obtained under steady conditions.

To function ideally, this device should be designed in such a manner that the mutual induction between its two windings is the same as the mutual induction existing between the cross-magnetic shunt winding and the armature winding with its series winding.

Let N_1 = total effective number of turns on the cross-axis of the generator carrying the welding current.
N_2 = total number of cross-shunt field turns.
n_1 = number of turns on the transforming reactor carrying the welding current.
n_2 = number of turns on the transforming reactor in series with the cross-shunt field.
F = cross-flux per ampere-turn of the generator
f = mutual flux per ampere-turn of the reactor.

The design of the transforming reactor should then satisfy:

$$f \times n_1 \times n_2 = -K \times F \times N_1 \times N_2$$

The minus sign is used, since the two windings on the transforming reactor support each other, whereas in the generator corresponding windings oppose each other. In order to eliminate all transients, K should be equal to 1; however, fractional values of K give very good transient performance.

Experience has shown that to stabilize the arc, a certain amount of series reactance in addition to generator reactance is necessary in the arc circuit. This additional reactance is supplied by shaping the magnetic circuit of the inductive device so as to enlarge its primary leakage. (Fig. 2) Thus the transforming reactor has two fluxes; namely, the mutual flux which links both the primary and the secondary windings, and the primary leakage flux interlinked with the primary alone.

Experiments have shown that this combination welds with great ease both for hand and automatic welding. It lays down the metal with ease and accuracy under all conditions met in welding, and produces welds of uniformity and strength.

◆ ◆ ◆

Electricity in Modern Dairy Plants

With the advent of the Electropure method of pasteurizing, in which electric current is actually passed through the milk, the modern dairy is taking its place among the important users of electricity. Other uses of electricity in such plants are also described.

By ***A. J. Dreux*** *and* ***H. C. Brunner***

Non-member
Rieck-McJunkin Dairy Co.
Pittsburgh

Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co.
East Pittsburgh

MODERN electrified dairies such as the main plant of the Rieck-McJunkin Dairy Company in Pittsburgh should be of particular interest to electrical engineers especially since the power survey recently made in that plant on the question of purchased power *vs.* gas and steam-engine generation. The desirability of the electric load for such a modern dairy plant is indicated by the fact that under the proposed operation, the average monthly power consumption would be 242,965 kw-hr. at 94.2 per cent power factor. The load demand is quite uniform throughout the year as indicated by the fact that the greatest maximum monthly demand is 962 kva. and the average maximum demand is 887 kva.

Under the proposed operation, all d-c. motors with the exception of those operating elevators would be replaced with three-phase, 60-cycle, 220-volt motors. Existing steam- and gas-engine-driven generators would be shut down and the present total electrical requirements purchased from the Duquesne Light Company, by whose power and steam survey division the study was conducted. Data and comparisons presented in this report indicate an annual saving of approximately $7,500 in favor of purchased power over present steam and gas-engine operation in which the annual power-plant operating charges are approximately $175,000. This saving is due principally to reductions in coal, labor, gas, and repairs.

Under present operation, the 680-ton capacity of refrigerating machines, and most of the power-plant auxiliary equipment, is steam-driven, and no immediate change in this arrangement is being considered by the dairy. The power survey therefore did not include a study of advantages obtainable by the electrification of this part of the plant although a few brief comments on the subject are included in this article.

Plants such as the Rieck-McJunkin main plant will average about fourteen receiving stations where the milk is cooled and fed to large heat-insulated tank trucks. The electric motors installed in each of these stations will total from 25 to 75 hp., depending upon whether or not the station also has milk-condensing equipment, butter churns, or ice cream equipment.

Upon arrival at the main plant, the milk (after recooling) is fed by gravity into the pasteurizing room, (Fig. 1) and collects in two small constant-level tanks equipped with float valves. The equipment shown in Fig. 1 occupies floor space of 18 by 30 ft. with a maximum height of 10 ft., and consists of six Electropure

---

From "A Modern Electrified Dairy Plant," (N . 31-58) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931.

units which pasteurize and cool to bottling temperature (40 deg. fahr.) 13,200 qt. of milk per hour.

In the Electropure process, pasteurization is accomplished by an electrical-conductivity method by actually passing electric current through the milk. The heat of pasteurization is generated within the body of the milk itself during the time the milk is being pumped through a rectangular chamber, the ends of which are formed by two carbon electrodes. These electrodes are connected to the conventional 220-volt power supply and for a 2,200-qt.-per-hr. unit, they are 32 inches long and four inches wide; they are spaced three inches apart. Such a unit consumes 48 kw. per hour.

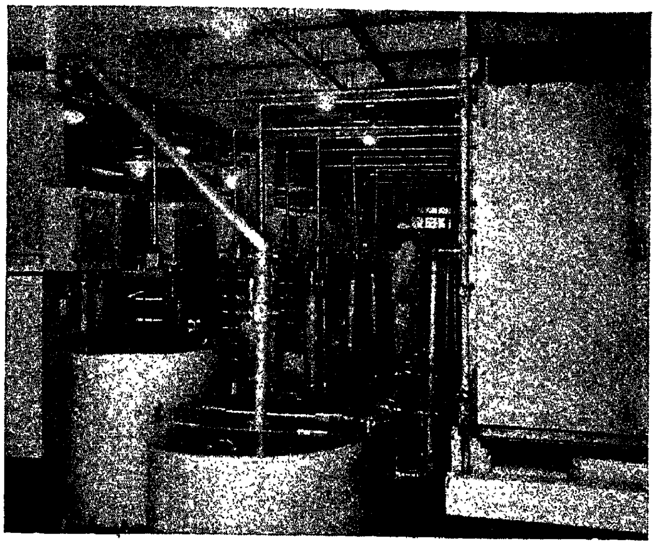


Fig. 1. A pasteurizing room equipped with six 2,200-qt. per-hr. Electropure process units

Electrical resistance offered by the milk to the flow of the electric current causes the temperature of the milk in the electrode chamber to be raised quickly. If either this electrical resistance of the milk or the power-supply voltage changes, the amount of heat generated within the chamber will change. In actual operation both are varying continually, and some means must be provided for regulating accurately the rate of milk flow to compensate for these, and to maintain a practically constant temperature at the outlet of the chamber. In addition, it is necessary to compensate for changes in the temperature of the raw milk supply. Limits of the practical operating range are set at the low-temperature limit by health codes, and at the upper limit, by the critical eye of the housewife. If the temperature drops too low, pasteurization will be incomplete; if the temperature rises too high, the amount of cream showing in the top of the milk bottle will be decreased.

On the six units shown in Fig. 1 the electrode chamber outlet temperature is regulated by means of a hand-operated micrometer valve and a controller which provides three speeds for the milk-circulating pump. The units in Fig. 2 are equipped with recently-developed supervised automatic control. This supervised automatic control was developed by Westinghouse to simplify the operation of the process, eliminate the possibility of human errors, secure an accuracy of temperature control not dependent upon the skill of the operator, and make unnecessary constant attention by an attendant.

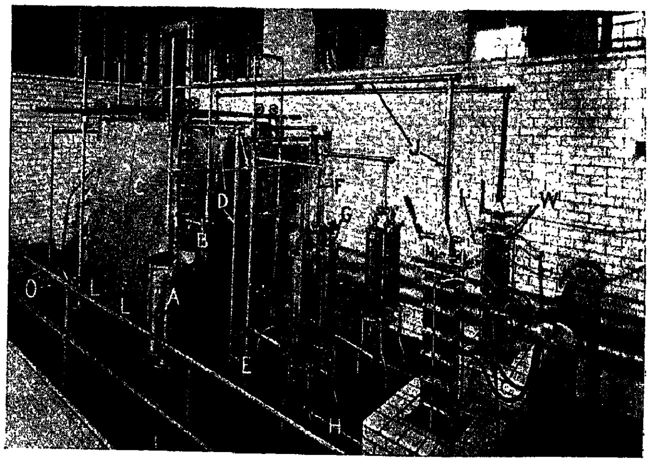


Fig. 2. Recent Electropure process installation equipped with supervised automatic control

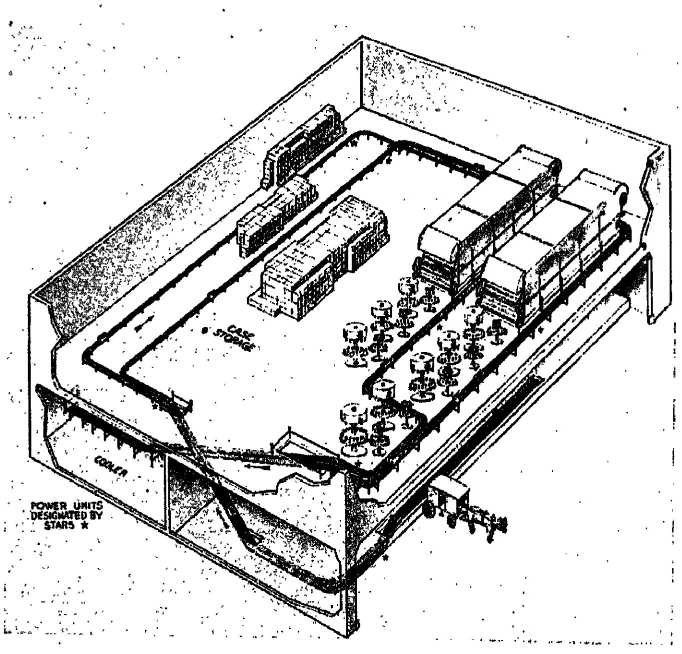


Fig. 3. An automatic case conveyer driven by eleven 2-hp. motors, conveys the returned empty cases to the bottling department and then to the cooling room

Should some abnormal condition cause undertreated milk to be circulated in the units equipped with these recently-developed controls, the control automatically stops the circulating motor and indicates to the operator what has occurred so that he may make the adjustment necessary to return the system to normal operation. This means that the operator may spend practically all of his time on other work; and since the control is accomplished entirely by adjustments in the electrical circuits, the control station may be located in a laboratory or any other room adjacent to the pasteurizing room.

In the Rieck-McJunkin plant, the cooled milk flows from the Electropure units to the bottle fillers by gravity, an automatic chain-conveyer system feeding fresh, clean bottles to and from the fillers (Fig. 3). This conveyer system is driven by eleven 2-hp. squirrel-cage electric motors, and its installation enabled the dairy to handle the same amount of milk in two hours less time with eight less men and two less bottle fillers.

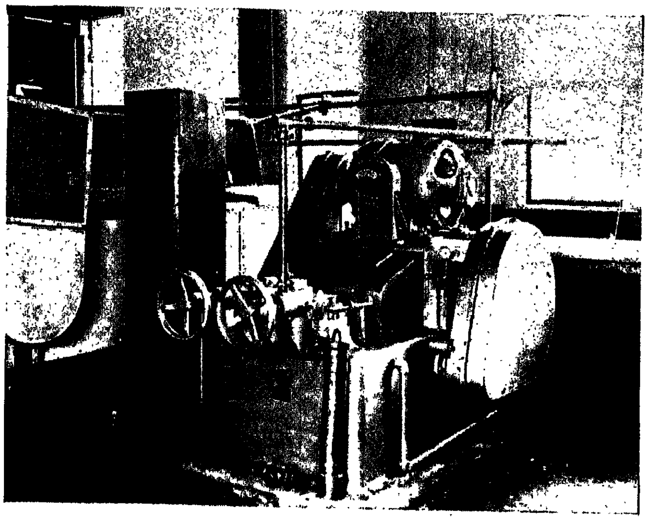


Fig. 4. An ice cream homogenizer which in reality is a special form of high-pressure pump. It is equipped with an ammeter to indicate the operating pressure

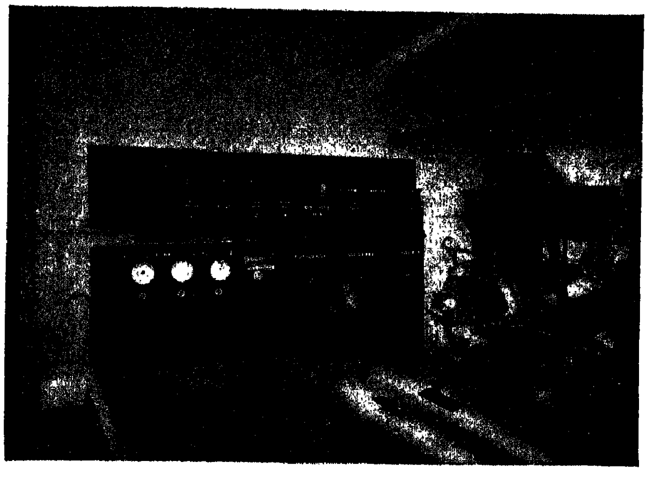


Fig. 5. Drawrite freezer meters and controls for regulation of the ice cream freezing process

The other milk products are obtained by similar careful processes, the details of which will not be given here. A few illustrations of the more important machines are presented, however, and their power requirements and load characteristics mentioned so as to give a more complete picture of the electrical apparatus.

The homogenizer (Fig. 4) is in reality a high-pressure pump which, depending upon its size, will require a motor of from 15 to 40 hp. By forcing the ice cream mixture through a specially designed orifice, this machine produces ice cream of even and fine texture.

In the freezing of ice cream, electric meters (Fig. 5) are used to record the freezing action. As the mixture freezes, the motor load increases; when the cream is properly frozen, the refrigeration valve is closed. The freezing is stopped, but the mixing continues until the whipping action has incorporated the correct amount of air to give the desired light, creamy appearance. This is known as the "over-run," and since the motor load decreases during this period the correct amount of whipping is also indicated by the meter.

Electrically-driven delivery trucks are frequently used by some of the large dairy plants, particularly those in cities where the routes are level and few hills are encountered. The ease of controlling the truck from either side, and the absence of gas fumes, make this type of truck especially desirable. Two 200-kw. motor-generators with a panel board (Fig. 6) are used for charging the batteries of trucks operating from a large Chicago dairy of approximately the same size as the Rieck-McJunkin plant.

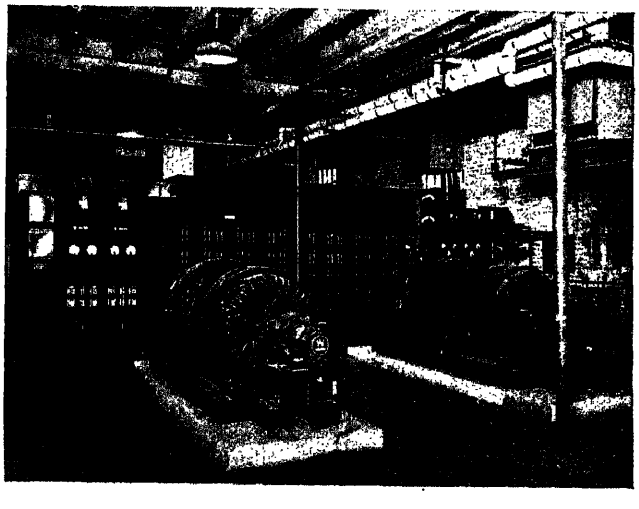


Fig. 6. Two 200-kw. battery-charging motor-generator sets and switchboard installed at the Borden dairy plant in Chicago for charging the batteries of electric milk-delivery trucks

Cracking Oil by Electricity

Low-grade oils formerly wasted now are "cracked" to form gasolines and other highly volatile oils. Some of the problems encountered in developing a reliable electrical process for accomplishing this are discussed in this article.

By Herbert R. Rowland

Member, A. I. E. E.

Moody Engineering Company, New York

FOR MANY YEARS, in this country and abroad, attempts have been made to use either silent corona discharge or the electric arc for the breaking up of heavier groups of hydrocarbons into lighter groups. It now is practical to manufacture gasoline by the corona method, the resulting product being a high-grade motor fuel.

In the cracking operation, heat must of necessity be supplied. When the electric arc is used heat is naturally furnished by the arc but is so intense that undesirable elements are formed which cannot be removed except at considerable loss and expense. When the corona method is used the amount of heat dissipated is too small to carry on the cracking operations and therefore heat must be supplied from some other source.

Probably the most consistent operations in electrical cracking have been carried on during the past thirteen years in Kansas City. This work was started using coronas produced by means of high-frequency circuits, but for many years insufficient gasoline was produced to prove the industrial or commercial worth of the process. This was due to two major causes; namely, the frequent breakdown of insulators resulting from the high temperatures used for vapor-phase cracking (900 to 1,150 deg. fahr.) and the extremely high power consumption which was due to losses in the attendant high-frequency apparatus, the over-all electrical efficiency of which was less than 0.5 per cent.

At this point in the development about seven years ago the writer was assigned the task of carrying on this work. At the outset it appeared both useless and unnecessary to continue with the costly and inefficient high-frequency method for producing the silent corona discharge.

The bibliography of the matter seemed to show quite conclusively that the voltage required for corona formation and silent discharge was governed mainly by (1) the size and composition of the wires or surfaces between which this silent discharge takes place, (2) the distance separating these two surfaces, and (3) the vapor tension of the enclosed medium.

Before making any major change in the characteristics of the electric circuit then in use, the writer consulted with the late Dr. C. P. Steinmetz, to whom he wishes to give full credit for the ideas, encouragement, and assistance he received from this conference. Early it was seen that the major part of the problem was concerned with voltage and insulation. Voltage required for silent corona discharge was found to be dependent upon both the size and composition of the wires or surfaces on which the phenomenon was to take place.

Steel, copper, nichrome, tungsten, and metal combinations, all have their different corona voltage characteristics. Other conditions being satisfied, metallic tungsten wire probably produces corona at a lower voltage for a given diameter than any other metal. However, due to its liability to oxidize when heated in an atmosphere containing even a small amount of air it was not suited for this work.

Nichrome-steel wire due to its extremely high elastic strength and its resistance to oxidation when heated in the presence of air was adjudged the most suitable metal.

The other side of the electric circuit consisted of the inside of a 12-in. pipe, it being necessary to handle in a completely enclosed system highly superheated volatile and explosive gases, such as vaporized oils.

The corona wire must be axially in the direct center of the reaction tube. Therefore it must be centered at the top of the tube by some type of insulator and at the bottom of the tube by another insulator which would hang as a weight on the wire, keep it axially taut in the tube, and prevent movement which might be caused by the flow of the vapors in the tube. A weight of ¾ lb. was found to be sufficient to keep the wire taut. It was finally found that No. 26 B&S gage was the smallest nichrome-steel wire that would support the ¾-lb. weight without stretching when heated to a temperature of 1,300 deg. fahr. This size and type of wire was therefore selected as possessing the best obtainable combination of the mechanical and electrical properties required for this work.

The next problem consisted of the selection of a suitable insulator; with proper allowances for safety factor an insulator for this work must meet the following severe requirements:

1. Operate continuously at 37.5 kv., 60 cycles without puncture.
2. Withstand a 45-kv. flashover.
3. Must be made of smooth material and built without petticoats so as not to have lodging places for local deposits.
4. Must not change shape or form at temperatures as high as 1,350 deg. fahr.
5. Must withstand this temperature on the bottom half, the upper half being at room temperature, without cracking.
6. Must have sufficient mechanical strength to prevent crushing when fastened securely in a stuffing box against hot vapor pressure.

From a paper informally presented before the A. I. E. E. Kansas City Section, April 22, 1930.

A study was made of the various materials from which an insulator of the foregoing requirements could be safely and economically manufactured. Glass, lava, and porcelain were tried, but it was found that these substances punctured at temperatures only slightly higher than the boiling point of water. These substances had a further extremely bad fault in that the part protruding from the reaction tube and projecting into the air, cracked and broke off when the part remaining in the tube was heated.

As a last resort fused quartz was tested and while the puncture temperature was only about twice that of other materials, the outer end of the quartz tube would not crack and break off when the enclosed part was heated to a high temperature. As long as the quartz was mechanically sound it was thought that if the insulator were made large enough it would act as a filler for an air-gap distance which would itself be of sufficient width to prevent a discharge between electrodes.

Accordingly many runs were made on enlarged insulators and while some of them operated satisfactorily for nearly 100 hr., others would puncture in less than 8 hr.

In order to separate the two electrodes still further the next step was to set the quartz insulator in a disk about 8 in. in diameter and one inch thick. While a combination of the tube and disk prevented puncture, in order to prevent leakage of the vapors past the disk it had to be placed in a stuffing box. Here it was found that quartz when heated and held firmly in one dimension would give no trouble from thermal expansion, but if confined in more than one dimension would shatter when heated. After several of these disks had broken, resulting in serious fires, this idea was abandoned.

Continued investigation led finally to the adoption of an oil-cooled insulator as shown in the accompanying illustration. As may be seen, this insulator consists of a tube of clear quartz of sufficient length to prevent flashover, enclosed over a part of its length in an envelope made from a larger diameter of quartz tubing. This outer envelope is fused to the inner tube at the bottom, the top being left open. Cooling oil is circulated in the annular space between the inner and outer tubes. An annular rubber cork is inserted in this space at the top of the outer tube through which two metal tubes sealed with a special cement extend into the cooling chamber.

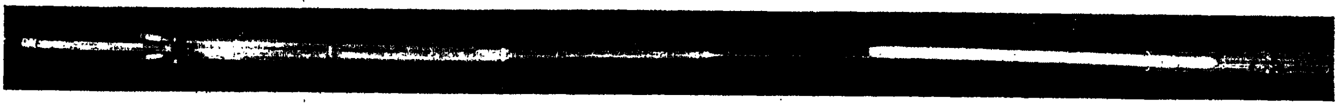
The outer ends of the tubes carry threads that will fit a ⅛-in. pipe-thread union. To these are connected well annealed copper tubing through which the cooling oil is led to and from the insulator. To prevent possible short-circuiting or electrical rupture on account of the metal tubes, a long piece of bakelite tubing is installed in each tube circuit which effectively breaks their electric continuity.

The central electrode runs down through the inner quartz tube, this electrode being made of flexible copper wire and brazed to the corona wire; this in turn is fused into the quartz, thus making a vapor-tight joint.

An insulator for use at the bottom of the reaction tube presented a much simpler problem, it was necessary only to provide sufficient weight to keep the wire taut and enough length to prevent flashover. This insulator has been made in two parts; a strip of metal containing a proper sized hole is first welded on the inside of the reaction tube so as to bring the hole directly in the center of the tube; into this hole is slipped a quartz thimble. Fastened to the corona wire is a quartz tube approximately 18 in. long, loaded with quartz sand until it weighs exactly ¾ lb. This tube is slipped through and hangs loosely inside of the thimble. The combination of tube and thimble gives great flexibility, combines a long flashover length with a small air-gap, and in case of any variation in the thermal expansion of either the reaction tube or the wire permits automatic adjustment. This combination has given no trouble except in those cases where the corona wire broke.

Apparatus for supplying high voltage is extremely simple; a 33-kv. step-up transformer is used connected on the low-voltage side directly to 220-volt, 60-cycle mains. This transformer contains sufficient built-in reactance so that in case of a short circuit on the high-voltage side there would be no abnormal rush of current. One high-potential lead is connected through disconnect switches to corona wires in the various reaction tube insulators, the other lead being connected directly to the reaction tubes and solidly grounded. A voltmeter connected across the primary terminals of the transformer, which ordinarily reads the impressed e. m. f. will read zero thus giving an indication of trouble in case of a punctured insulator or when a broken corona wire touches the surface of the reaction tube.

It is not thoroughly understood just what part this



Insulators for oil cracking by the silent corona discharge method. In service the assembly normally hangs suspended from the left-hand end as shown here silent corona discharge plays in the cracking process; however, three theories have been advanced as follows:

1. More perfect ionization of the vapors is produced by the corona discharge and therefore a more complete cracking takes place. This is known as the electrothermal theory.

2. Corona discharge sets up an agitation of the vapors and a possible electronic bombardment of oil atoms against the hot walls of the cracking tube, thus insuring a more perfect heat cracking. This is called the electromechanical theory.

3. The electroprecipitation theory, according to which gasoline is precipitated by the corona from the other vapors in the tubes, thus causing a clearer separation of the gasolines from the uncracked oils.

Since the amount of power used for five tubes handling a total of ten barrels of oil per hr. at a power factor of not more than 10 per cent is less than one kilowatt, this appears too small to accomplish a great deal of ionization. In the case of the electroprecipitation theory it seems impossible to precipitate a vapor from a vapor, since in these tubes at the temperature maintained all of the oil passing through must be in vapor form.

On the other hand it seems entirely feasible, to consider an electron moving through an appreciable distance in space and either carrying with it or driving before it a molecule of hydrocarbon in the vapor form. At last a surface is reached which permits no further movement of the oil vapor molecule, but which readily absorbs the electron. The impact of this molecule can be very great and the pressure at impact can run into large amounts, thus causing cracking by both pressure and heat when the force is expended against the hot wall of the reaction tube. It therefore seems that the violent agitation of the vapors by the silent corona discharge is undoubtedly of prime importance in the complete cracking of the vapors. These facts would tend to support the electromechanical theory.

The gasoline produced by this process constitutes in itself, without blending the saturate, unsaturate, and aromatic groups, a fuel that has not only high antiknock value but also more miles per gallon than "doped" fuels.

◆ ◆ ◆

Field Test on Thyrite Arresters

A study of the performance of Thyrite lightning arresters when subjected to artificial lightning discharges of 1,500,000 volts has been made. The results obtained under different operating conditions are discussed in some detail.

By K. B. McEachron and E. J. Wade

Member A. I. E. E. Associate A. I. E. E.

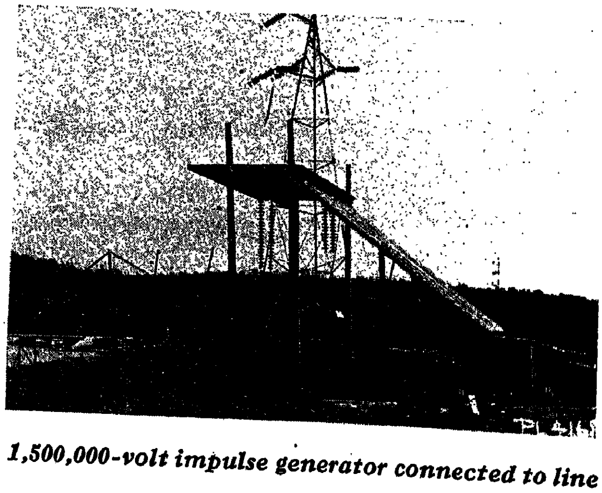
General Electric Company
Pittsfield, Mass.

STUDIES with natural lightning determine the form of waves which may appear in service, while artificial lightning (since it can be repeated at will and studied completely) is best used to disclose the performance of lines and apparatus.

During the last two years, investigations have been made in cooperation with the Consumers Power Company on their S-19 line which is about 45 mi. long. Various subjects were studied but this paper deals only with the tests made on lightning arresters during the summer of 1930.

A portable cathode ray oscillograph was especially designed for this work by one of the authors (E. J. Wade). It is of the cold-cathode type and incorporates many features making for rapid and reliable operation.

The impulse generator was located at the end of the line and consisted of 60 banks of oil capacitors, each of 0.5 μf., and charged in parallel to 25 kv. The open-circuit voltage when discharged in series was 1,500,000

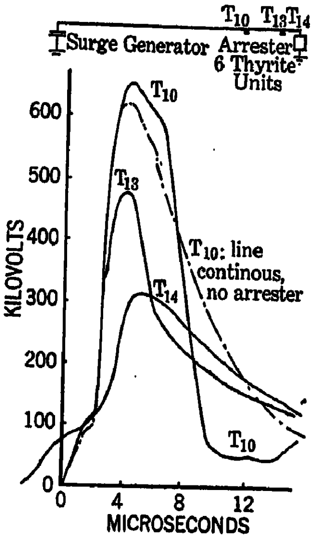


1,500,000-volt impulse generator connected to line

From "Field Tests on Thyrite Lightning Arresters," (No. 31-11) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

volts. The lightning arresters being studied were located 1.5 mi. away from the impulse generator. This distance was chosen as being far enough to give true traveling-wave conditions but not far enough for the waves to be reduced too much by attenuation.

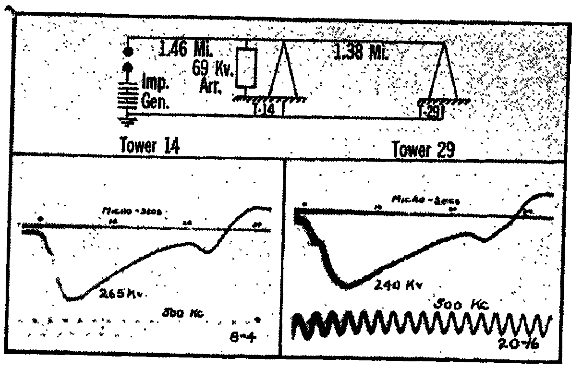
Methods of calculating the performance of the Thyrite arrester under any assumed condition have been developed and the first tests were made to check these calculations for ratings up to 220 kv. under three line conditions; *i. e.*, line continuous, line open, and two lines in parallel. These correspond respectively to the arrester being located at a point on a line, at the end of a single line, and connected to a bus with two outgoing lines. The agreement between the test results and calculated values is very good. It was found justifiable to add the ground resistance in calculating the arrester performance. If the arrester and apparatus grounds are bussed together the protection will be independent of ground resistance.



Impulse wave-shape at points between generator and arrester. Note that protection does not extend far beyond the arrester

The effect of a flashover on the line before the wave reaches the arrester is an interesting condition which is met with very frequently in practise. Tests were made to show what happens both without any arrester and with a 69-kv. arrester located three spans beyond the flashover point, which consisted of five insulator disks. When the arrester was connected, the flashover was delayed two and one-half microseconds and the oscillations were effectively suppressed. The point of flashover was too far away to be protected by the arrester.

Another series of tests of great interest was the measurement of voltage at various distances from the arrester. It was found that arrester protection does not extend much beyond 500 ft. for the wave used. Even if the arrester had reduced the potential to zero the zone of protection would not have been appreciably extended. The wave shape at distances beyond the arrester is the same as at the arrester, being changed only by attenuation.



Impulse wave-shape at points beyond the arrester showing that attenuation is apparently the only influencing factor

The question of arrester location and length of connections is of fundamental importance, and a number of different arrangements was tried. These included the so-called "hair-pin" loop, connecting the arrester in one or two stacks, long arrester connections versus long transformer connections, and the effect of a capacitance to simulate station apparatus. All the results can be explained by giving proper consideration to the effect of circuit length. The effect of the arrangement and turns or bends in the circuit was shown to be negligible.

It is of primary importance to locate the arrester close to the apparatus to be protected but if it must be at a distance, it is better to have long transformer connections rather than long arrester connections. This is because with long arrester connections the transformer reflects the incoming wave, while with short arrester connections, the transformer reflects only the arrester potential. The excess voltage which may be introduced by a certain length of connection does not depend upon the arrester rating; however while a given increase in potential may be considered negligible on a high-voltage arrester protection offered by a low-voltage arrester may be insufficient.

This investigation shows that Thyrite arrester performance for any given impulse wave can be closely calculated if the length of the connections and the ground resistance are known. Several hundred oscillograms have been taken, making available much valuable information regarding the application of lightning arresters.

These tests are part of a large program of transient investigation conducted jointly by the Consumers Power Company and the General Electric Company. The field work was in charge of E. J. Wade and J. R. Eaton, who were assisted by Messrs. W. J. Rudge, O. Brune, C. C. Tanner, E. J. Shimek, D. Blackwell and others.

Vertical A-C Distribution Networks

With buildings from 500 to 1,000 ft. in height becoming common in large cities, load densities have increased to many times their former values. Vertical low-voltage networks supplied from transformers located on different floors of these high buildings, are well suited to cope with such extreme concentrations of load.

By A. H. Kehoe and *Bassett Jones*

Fellow A. I. E. E.
United Elec. Lt. & Pwr. Co.
New York

Member A. I. E. E.
Meyer, Strong, & Jones
New York

VERTICAL NETWORK SERVICE was first offered by companies comprising the New York Edison System in December 1928, at which time the arrangement was accepted by the owners of the Irving Trust Company building at 1 Wall Street as suitable for the electric supply to that building. Similar arrangements were made almost simultaneously with several other large buildings which at that time either were being planned or were under construction. Since then, this type of service has been adopted for practically all new buildings in New York City, of more than forty stories, as well as for some lower structures. A few high buildings of the tower type having comparatively small floor areas have been built recently, but in these cases there is only a slight advantage in this specific service.

On January 1, 1931, there were in Manhattan ten completed buildings with vertical network service completely installed, comprising a total connected load of about 31,700 kw. Seven more buildings incorporating this service are now under construction. In these the total connected load will be about 14,300 kw. In addition, five new buildings are being planned with power and lighting requirements totaling about 30,000 kw., and in these it is expected to use the vertical network systems. The accompanying table gives detailed information regarding typical installations.

HIGH-VOLTAGE SUPPLY ABOVE THE STREET LEVEL

For densely-loaded urban areas in many localities a-c. distribution in recent years has taken the form of multiple-feed networks. The first installation of this type in New York City was completed in 1922. This arrangement provides an economical and reliable system which satisfies the electrical distribution requirements of most urban districts. In many cases these networks are of the three-phase, four-wire type, and are operated at 120/208 volts. Distance from the distribution transformers over which energy at such voltages can be economically transmitted, however, is definitely limited if both a reasonable amount of copper for distribution and satisfactory regulation are to obtain.

In a number of cities there has been a decided tendency in recent years to increase the height of buildings; this has resulted in an increase of total floor area to many times the ground area, with a corresponding increase in the electrical density of distribution. While in these large buildings the electrical-load density per sq. ft. of floor area has increased somewhat, the percentage increase, of course, is much less than the increase in load density based on ground area.

While this load may be considered in the light of an extremely dense load at the street level, yet the area may be so located that it is cheaper in over-all costs to supply it from distribution transformers located in upper floors of the building than to supply the energy at 120/208 volts from the street distribution system. Thus it might be considered that the utility has been presented with the equivalent of a large addition to its territory. This will be understood readily when it is realized that building heights of from 500 to 1,000 ft. above the street now are becoming commonplace and such buildings require large banks of elevators, the motors of which are located in the upper stories of the building. Some of these elevators have motors ranging in size from 100 to 150 hp. for the higher buildings, with short period demands several times these values.

With such dense loads at an appreciable distance from the street level, it is found to be definitely economical in over-all costs to distribute with multiple high-voltage supplies feeding a low-voltage network throughout the building. This system is identical in principle to the street network system, as may be seen in the accompanying illustration.

ECONOMIC ASPECTS

Comparative estimates of building wiring costs for the Irving Trust Company Building mentioned previously, showed a saving of $35,000, for the vertical network system as compared with the system in which the service transformers are all located in the

---

From "Vertical Networks in Metropolitan Office Buildings," presented informally at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931.

basement. However, some modifications in plans were made at the request of the local inspection authority and all of the above estimated saving was not realized.

In the Empire State Building the network system has been applied to the individual floors. Four-wire 120/208-volt feeders from one or more centers of distribution, where they are fused, feed into a four-wire main, circling each floor. Unfused branch circuits are tapped off this main to feed one or more "bays."

With the radial system of building wiring, enough copper must be run from the house switchboard to each load group (say three floors, for lighting, elevator bank, or other motor group) to carry the maximum load of that group. With the network system using a tie bus between transformer banks, the advantage of load diversity is realized in reducing the amount of copper required. The utilization factor can be worked out by the known probability factors for the case (see Power Calculations for Elevators by the Method of Probabilities, *G. E. Review*, October-November 1930). This method applies not only to elevators but is applicable also to variable loads of any kind for which an "operating factor" can be determined. The fifteen-minute demand (r. m. s. value of the load over this period) on the usual elevator bank is about thirty-five per cent of the connected load. With the old radial system of wiring a separate feeder, or duplicate feeders, having at least the load capacity of the fifteen-minute demand on each bank must be run to each such bank.

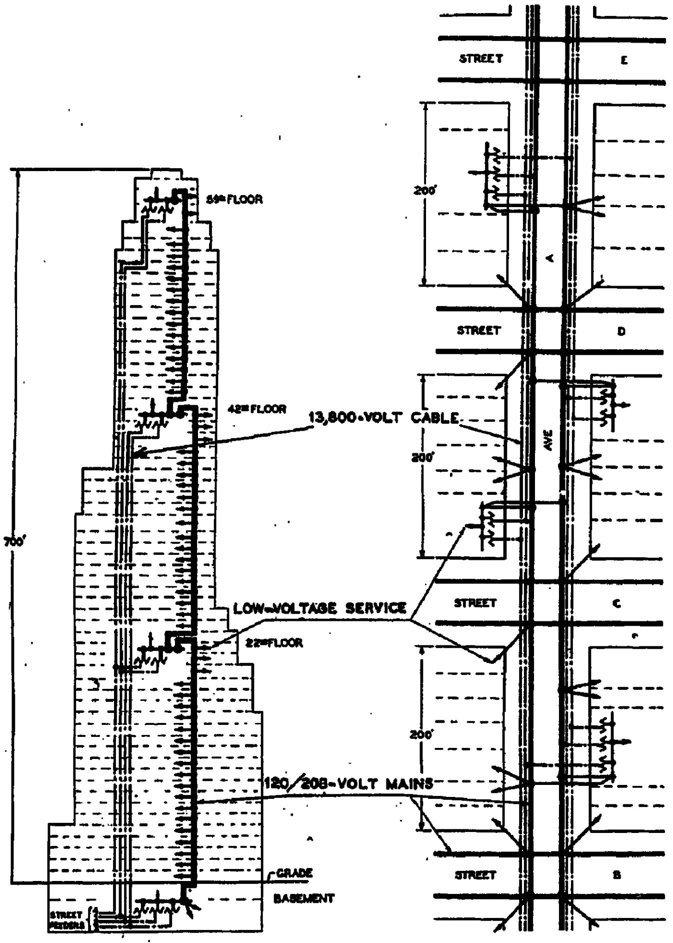
OWNERSHIP OF EQUIPMENT

Since a distribution installation in a building cannot be considered as having the permanency of a street system, (it being subject to the whims of the building owners) and since it cannot be utilized for any service other than for that particular building, there is naturally a distinct limitation to the amount of investment that the utility company can make for such an installation. On the other hand, if the vertical distribution network is used instead of distributing throughout the building from street services the building owner realizes a definite saving in building wiring. It is thus reasonable to have a different division of expense for vertical distribution from that which would be used in the case of general distribution throughout a city.

The division used in New York is to have the utility company supply, and own and maintain the high-voltage cables and the distribution transformers with their associated network equipment. These are placed in position by, and at the expense of, the building owners in ducts and vaults supplied as part of the building installation. All low-voltage distribution conductors and ducts except the 120/208-volt a-c. network ties from the street mains to the first distribution point within the building are owned and installed by the building owners. While the building owners install the transformers and high-voltage cables, all connections are made by the utility company. In case the building is abandoned this division makes it possible for the utility company to recover all its equipment, and the costs incurred are not materially different from those in supplying the building directly from the street system. In the case of high buildings the cost of the wiring installation is considerably reduced. Certain expense, of course, is incurred in securing space for transformer vaults, but in most cases space yielding little of value can be used for this purpose.

LOW-VOLTAGE TIE CONNECTIONS

If all conditions of supply for vertical distribution were the same as those found in the common network system, the installations would be unusual only from the standpoint of establishing the division of ownership and maintenance between the building owner and the utility. However, as the types of installations made to date will indicate there are numerous conditions which cause these services to differ. The vertical networks



TYPICAL HIGH BUILDING
VERTICAL NETWORK SERVICE

TYPICAL CITY BLOCKS
NORMAL STREET SERVICE

Schematic diagrams of street and vertical distribution networks showing similarity between the two systems

TYPICAL VERTICAL AND HORIZONTAL NETWORK SERVICES

Name and type of building	Stories	Gross floor area (sq. ft.)	Total feeders supplying service		Vault location (floor)	No. of banks	Size of banks (kva.)	Initial capacity in vault (kva.)	Character of inter-vault ties	Terminal points of inter-vault ties	Sizes of inter-vault ties	Load and estimated demand	Status of installation
			13.8 kv.	3 kv.									
Chrysler	77 and Tower	1,160,000	5	3	Basement	4	300	1,200	Non-fused	St. N. W.-Base	7–4/0	Light =2,460 kw	Complete
(Office)					30th	4	300	1,200	None	Base-30th	None	Power =3,378 hp	Complete
					60th	4	150	600	Non	30th-60th	Non	Demand =2,500 kw	Complete
					74th								Held pending flood light development)
Bank F Manhattan	72 and	800,000	5		Basement	5	300	1,500	Non-fused	St. N. W.-Base	7–4/0	Light =3,241 kw	Complete
(Bank & Office)	Tower				15th	5	150	750	None	Base-15th	None	Power =3,765 hp	Complete
					65th	5	150	750	None	15th-65th	None	Demand =2,000 kw	Compl te
Daily News	36	723,500	4		Basement	4	150	600	Non-fused	St. N. W.-Base	2 (7-4/0)	Light =1,115 kw	Complete
					25th	4	150	600	None	Base-25th	None	Power =1,292 hp Demand = 900 kw	Complete
(Office and Printing Plant)	9	314,090	5		Base	5	300	1,500	Non-fused	St. N. W.-Base	7-4/0	Light = 639 kw	Complete
					2nd	4	300	1,200	Fused Non-tapped	Base-2nd	2(7-4/0)	Power =2,782 hp Demand =1,500 kw	Complete
Irving Trust Co.	50	500,000	4		Basement	4	150	600	Non-fused	St. N. W.-Base	7-4/0	Light =1,379 kw Power =4,047 hp	Complete
(Bank & Office)					21st	3	300	900	Fused & tapped	Base-21st	4(4-300 MCM V.C.)	Demand =1,500 kw	Complete
					37th	3	300	900	Fused & tapped	21st-37th	4(4-300 MCM V.C.)		Complete
Salmon Towers	60	649,403	4		Basement	3	300	900	Non-fused	St. N. W.-Base	7-4/0	Light = 974 kw Power =1,928 hp.	Complete
					22nd	2	150	300	Fused & tapped	Base-22nd	2(4-300 MCM V.C.) 1(4-400 MCM V.C.)	Demand = 940 kw	Complete
(Office)					42nd	2	150	300	Fused & tapped	22nd-42nd	3(4-250 MCM V.C.)		Complete
					59th	3	150	300	Fused & tapped	42nd-59th	3(4-3/0 V.C.)		Complete
Lefcourt	43	703,000	4		Basement	2	150	300	Non-fused	St. N. W.-Base	7-4/0	Light =1,214 kw	Complete
(Apt. Hotel)					22nd	2	300	600	Fused & tapped	Base-22nd	2(11-4/0)	Power = 770 hp	
					42nd	2	150	300	Fused & tapped	22nd-42nd	2(8-4/0)	Demand = 522 kw	On Bank cut in Complete
(Office)	30	330,000	4		1st	1	300	300	Non-fused	St. N. W.-1st	7-4/0	Light = 650 kw	Complete
					21st	3	300	900	Fused Non-tapped	1st-21st	4-600 MCM	Power =1,090 hp. Demand = 630 kw	Under construction
Farmer's Loan & Trust C	56	863,821	4		Basement	4	300	1,200	Non-fused	St. N. W.-Base	7-350 MCM	Light =1,296 kw Power =4,201 hp.	Complete
					21st	4	300	1,200	Fused Non-tapped	Base-21st	4-500 MCM	Demand =1,780 kw	Under construction
(Bank & Office)					54th	3	300	900	Fused Non-tapped	21st-54th	4-500 MCM		Under construction
	37	800,840	3		Basement	2	450	900	Non-fused	St. N. W.-Base	2(7-350 MCM)	Light =1,322 kw Power =1,430 hp.	One bank cut in
(Office & Loft)					36th	3	300	900	Fused Non-tapped	Base-36th	2(3-800 MCM) 2(1-400 MCM)	Demand =1,110 kw	Two banks cut in
Nels n Towers	48	477,720	3		Basement	3	300	900	Non-fused	St. N. W.-Base	1(7-4/0) 1(7-2/0)	Light = 715 kw Power =1,420 hp.	Complete
(Office & Loft)					48th	3	300	900	Fused Non-tapped	Base-48th	4-500 MCM	Demand = 715 kw	Complete
R. C. A.	50	462,288	3		Basement	3	150	450	Non-fused	St. N. W.-Base	7-350 MCM	Light = 693 kw Power =1,577 hp.	Two banks cut in
					22nd	3	150	450	Fused Non-tapped	Base-22nd	4-500 MCM	Demand = 727 kw	Under construction
(Bank & Office)					49th	3	150	450	Fused Non-tapped	22nd-49th	4-500 MCM		Under construction
Empire State	85 and Tower	2,754,180	5		Basement	5	600	3,000	Non-fused	St. N. W.-Base	2(7-350 MCM)	Light =4,431 kw Power =9,593 hp.	4 banks cut in
					41st	4	600	2,400	Fused Non-tapped	Base-41st	4-500 MCM	Demand =5,031 kw	Complete
(Office)					84th	4	600	2,400	Fused Non-tapped	41st-84th	4-500 MCM		Complete
City Service	63	1,046,000	4		Basement	3	450	1,350	Non-fused	Cedar St. N. W. Base Pine St. N. W. Base	2(7-350 MCM) 2(7-350 MCM)	Light =1,345 kw Power =4,725 hp. Demand =1,963 kw.	Planning
					18th	3	300	900	Fused & tapped	Base-18th	2 tubular buses		Planning
					31st	3	300	900	Fused & tapped	18th-31st	1 tubular bus		Planning
(Office)					61st	3	300	900	Fused & tapped	31st-61st	1 tubular bus		Planning

TYPICAL VERTICAL AND HORIZONTAL NETWORK SERVICES—*Continued*

Name and type of building	Stories	Gross floor area (sq. ft.)	Total feeders supplying service		Vault location (floor)	No. of banks	Size of banks (kva.)	Initial capacity in vault (kva.)	Charatcer of inter-vault ties	Terminal points of inter-vault ties	Sizes of inter-vault ties	Load and estimated demand	Status of installation
			13.8 kv.	3 kv.									
Port of N. Y. Authority Inland Stat. No. 1 (Offices & Stores) & Loft & (Warehouse)	15	Offices & Stores, 8th & 9th Aves =273,966 Loft Mfg. =997,767 Warehouse =997,767 Total =2,269,500			Base (8th Ave.)	0	0	Sec. Ser. Pt.	Non-fused	St. N. W.-Sec. Ser. Pt.	4(3-500 MCM) (1-4/0)	Light =2,258 kw Power =7,775 hp. Demand =4,147 kw	Planning
					Roof (8th Ave.)				Non-fused Non-tapped	Sec. Ser. Pt. Roof(8th Ave.)			Planning
					Base (center)				Non-fused	St. N. W. Base (center)	4(3-500 MCM) (1-4/0)		Planning
					Roof center)				Non-fused Non-tapped	Roof (c)-Base (c) Roof (c)-Roof (8th) Roof (c)-Roof (9th)			Planning
					Base (9th Ave.)	0	0	Sec. Ser. Pt.	Non-fused	St. N. W.-Sec. Ser. Pt.	4(3-500 MCM) (1-4/0)		Planning
					Roof (9th Ave.)				Non-fused Non-tapped	Sec. Ser. Pt. Roof (9th Ave.)			Planning
N.Y.C.R.R. St. John's Park Freight Terminal	12	3,529,000			3rd (Clarkson St.)				Non-fused Non-fused Non-tapped	St. N.W.-3rd(Clar) 3rd(NC)-3rd(Clar)	4(3-500MCM;1-4/0)	Light =1,484 kw Power =5,666 hp Demand =2,035 kw.	Planning
					3rd (N. Cent.)				Non-fused Non-fused Non-tapped	St. N.W.-3rd(N.C.) 3rd(S.C.)-3rd(N.C.)	4(3-500MCM; 1-4/0)		Planning
					3rd (So. Cent.)				Non-fused Non-fused Non-tapped	St. N.W.-3rd(S.C.) 3rd(Sp.-3rd(S.C.)	4(3-500MCM;1-4/0)		Planning
					3rd (Spring St.)				Non-fused Non-fused Non-tapped	St. N.W.-3rd(Sp.)	4(3-500MCM-1-4/0)		Planning
(Freight Terminal)													

used so far may be classified as follows according to the arrangement of secondary connections within the building:

1. Isolated or spot networks, also called junior networks in which the energy used at any one point in the building is supplied solely from a plurality of step-down transformers at a singl location, there being no secondary ties to any other network.

2. Networks with untapped low-voltage ties wherein the ties connect to other sources and therefore a multiplicity of step-down transformers at any one location are not required. In this case, however, service has to b supplied from the one location over special utilization feeders in the same manner as with a spot network.

3. Networks with tapped ties, the ties being used to distribute load to the several floors between transformer locations.

Each of these types of installation has been used to meet conditions which existed at the time the installations were planned. None of the tapped ties has been installed without fuses. Recent installations, however, are being made with untapped and unfused ties, installed in conduit surrounded by two or more inches of concrete; and in such cases, the building service is supplied locally from each step-down location.

FUTURE CONSIDERATIONS

One of the advantages obtained with vertical network service is the ability to increase the electrical capacity in the building at any time without expensive reconstruction of the original wiring, since each of the several high-voltage cables supplying the building are required for mechanical reasons to have much greater load-carrying capacity than is needed to serve any of the buildings contemplated up to the present time. Of course, the installation of additional distribution transformers would be required either in existing vaults or at new locations nearer the utilization point than the existing vaults; and in addition there would be required the necessary utilization wiring to deliver the new energy to the places in the building where it would be used. Such a procedure is much simpler and less expensive than would be required if the increase were to be supplied from the street network.

All vertical high-voltage feeder installations planned to date have used a dry type of three-conductor shielded cable with an outside wrapping of steel wires with which the cable is held up at the top of its run. It is possible (and obviously desirable) that future developments should make it feasible to use standard types of high-voltage cables for this purpose.

Considering the operating experience in New York City covering a period of about two years, the vertical network installations being made, are regarded to be more than adequate for the service requirements now foreseen. Improvements in methods and in equipment which will simplify the wiring installation and reduce cost may be expected in the future as inspection authorities, architects, and supply company engineers become better acquainted with the special requirements of this type of installation.

News
Of Institute and Related Activities

A-C Network, Industrial Interconnections, System Grounding Are Subjects of Pittsburgh Meeting

IF HEAVY ATTENDANCE and widespread discussion are indicative of the success of technical sessions, then the Pittsburgh District meeting must be adjudged conspicuous in this achievement. Held March 11-13, 1931, with headquarters at the Wm. Penn Hotel, Pittsburgh, it was sponsored jointly by the Institute's Middle Eastern District and the Association of Iron and Steel Electrical Engineers. Official registration exceeded 450, and attendance at several of the sessions was more than 500.

Inspection trips carefully planned to supplement the technical sessions added materially to values and interest. On Thursday evening, March 12, a banquet and dance was held under the joint auspices of the meeting and the Engineers' Society of Western Pennsylvania (Pittsburgh). With W. B. Stellmire (General Electric Company, Pittsburgh) toastmaster, the three speakers on the banquet program were Wm. S. Lee, president of the Institute, Dr. L. A. Hawkins, (General Electric research laboratory) the "Larry" Hawkins of radio fame, and E. C. Stone, vice-president of the Institute's Middle Eastern District.

Important details of the technical sessions are given in the following items. A résumé of discussions will appear in an early issue of ELECTRICAL ENGINEERING.

A-C. Network Symposium Attracts Wide Attention

Two out of five technical sessions were devoted to six papers and extensive, prepared discussion pertaining to the development of the a-c. network in electric power distribution. Three of these papers dealt with the development of underlying theory, having to do with low-voltage electric arcs; the second group of three papers related to the physical and economic aspects of the network idea itself.

Discussing "Burn-Off Characteristics of A-C. Low-Voltage Network Cables," George Sutherland and D. S. MacCorkle, of the New York & Queens Electric Light & Power Company, described extensive tests made to determine the characteristics of the clearance of faults in different types of a-c., low-voltage-network, copper-conductor cables installed in accordance with present standards of underground construction. Upon analysis of their test results and other data, the authors reached the following conclusions:

1. If A 3,000-ampere current is available, faults in the class of point contacts occurring in single-conductor, low-voltage cables operating at voltages from 120/208 usually clear within a few seconds irrespective of conductor size.
2. Copper-to-copper faults in single-conductor, low-voltage cables usually clear at the point of fault within one minute or less (for example, 3,000 amperes on 4/0 cable).
3. Size for size, the burn-off characteristics of non-magnetic-sheath cables dropped at random in a trench are the same as those of cables installed in 4-in. non-metallic ducts.
4. The burn-off characteristics of multiple-conductor, buried, non-magnetic-sheath cables make that type of construction undesirable for low-voltage, a-c. network distribution.
5. Analyses show no appreciable difference between oiled-paper and rubber insulation in the explosiveness and inflammability of gases produced by lead-covered cables.

J. Slepian and A. P. Strom of the Westinghouse research laboratories presented the subject "Arcs in Low-Voltage A-C. Networks." They reviewed the information pertaining to the extinction of a-c. arcs at current zero, and defined arc-reignition characteristics and circuit-reignition characteristics. Based upon studies of arc-reignition characteristics of short arcs between metal electrodes and non-adjacent to installation, the authors concluded that such arcs are incapable of interrupting practical low-voltage a-c. network circuits. They ascribed the extinction of arcs in practical network cables to the deionizing action of gas blast arising from burning insulation. It is claimed that experiments with arcs in cables, and arcs between parallel plates remote from insulation in some cases and closely bounded by insulation in other cases, confirmed this view. The authors stated that inorganic insulating materials also may assist in arc extinction through the generation of gas blast arising from their decomposition. In this connection boric acid was found to be the most effective material. It was stated also that the charring of organic insulation may be expected to cause an insulation to lose its arc-extinction-aiding characteristics.

Laboratory results bearing upon the "Reignition of Metallic A-C. Arcs in Air," were presented by S. S. Attwood and W. G. Dow, of the University of Michigan, and W. Krausnick, of Ohio Northern University. The authors were in search of experimental evidence of the current-voltage-time relations that exist during the period when an a-c. arc between metallic electrodes passes through its cyclic current zero. Twenty-nine cathode-ray oscillograms revealing certain characteristics of these relationships were presented. The authors stated that during the current-zero period the arc-electrode voltage is determined by the circuit constant, and rises until the electrode voltage reaches the breakdown or reignition value determined by the deionizing influences at work while the arc is extinguished. Alteration of the circuit constants permits a variation in the rate of voltage rise, with a consequent change in the reignition voltage. In the opinion of the authors the action of a circuit breaker in extinguishing an arc is greatly influenced by the presence of adjacent load circuits and by the presence of distributed inductance and the capacity in the connecting lines.

Some typical applications of the network distribution idea to power distribution within tall office buildings were outlined by A. H. Kehoe of the United Electric Light & Power Company, New York, and Bassett Jones, consulting engineer, New York. This paper appears practically in full on pages 292-95 of this issue.

C. T. Sinclair and R. M. Stanley, of the Byllesby Engineering & Management Corp., Chicago, presented their design of "A Primary Network." The primary network was characterized by its proponents as setting up the means for system growth and expansion, very largely obviating the need of extensive and expensive system planning. The primary network described is similar in general characteristics to the low-voltage network, particularly in so far as the inter-connection of the secondary mains is concerned. The authors contend that in spite of the fact that two transformation steps are required in the primary network described, compared with the one required in the low-voltage network the primary network has economic possibilities which should be considered seriously for areas of medium-load density. Such a network now is in course of construction in the Pittsburgh area and many persons interested took advantage of an inspection trip arranged to demonstrate this feature.

"The Philadelphia A-C. Network System," was described by H. S. Davis, and W. H. Ross, of the Philadelphia Electric Company. The system in question consists of sectionalized primary-loop feeders supplying a fused-secondary network. At present there are twenty-four of these feeders in operation with a normal total operating capacity of 32,540 kva. The feeder peak thus far experienced was reported to have been 27,600 kva. As a a result of five years of operating experience, during which period normal load growth and developments have been cared for, the authors have reached the conclusion that the system adopted has proved amply flexible to meet changing conditions, and that operating experience has been completely satisfactory under all conditions including times of faults on the network or elsewhere on the system.

Symposium On System Grounding

"Present Day Practise in Grounding of Transmission Systems," was comprehensively outlined in a committee report presented by C. A. Powel of the Westinghouse Electric & Manufacturing Company, chairman of an A. I. E. E. subcommittee on grounding.

J. E. Clem, General Electric Company, in his paper "Reactance of Transmission Lines with Ground Return," presented an analysis of a theoretical circuit consisting of any number of line conductors in parallel with a return to earth, and any number of ground wires in parallel. The paper is an added contribution of this author toward simplication of the calculation of ground faults, an essential factor in the prediction of system stability limits. In addition to his analytical study, the author presented confirming field test data and suggested a method of predicting the impedance of the fundamental circuits of a conductor with a ground return.

A "Fundamental Basis for Distance Relaying on Three-Phase Systems," was described by W. A. Lewis of the Westinghouse company, and L. S. Tippett, formerly of the same company. As a result of an extensive investigation into the subject, and based upon equally extensive supporting mathematics, the authors reach the conclusion that:

1. Conventional methods of distance relaying are subject to errors other than those caused by fault impedances.

2. Such errors may be eliminated in relays protecting against line faults by the use of the proper delta-connection of current transformers or relays.

3. That such errors may be eliminated in relays protecting against ground faults by the use of voltage or current compensation.

4. The limitation of application of distance relaying is the error introduced by the presence of fault impedance, which affects both impedance and reactance relays, but each to a different extent.

5. Distance relaying may be made to approach even more closely the desired relaying ideal and that within the limits of its application it should give satisfactory protection regardless of generator capacity or system conditions.

Under the title "Power System Voltages and Currents Under Fault Conditions —Effect of Sequence Impedances" R. D. Evans and S. H. Wright of the Westinghouse company presented the results of an investigation of the general characteristics of power systems under unbalanced fault conditions, giving particular attention to the range of voltage and current that may exist under such conditions. The authors made their analysis by the method of symmetrical components, giving attention to the range of the sequence impedances of power systems. They presented numerous curves and in general gave their results in a form offering a direct comparison of the characteristics of different systems. As a result of their study the authors have concluded that on three-phase systems:

1. The currents and the voltages under abnormal conditions may vary over a wide range depending upon the sequence impedances and the location and character of the fault.

2. The line-to-ground voltage may rise to twice the normal line-to-neutral voltage, and the ratio of line and ground current to the three-phase short-circuit current may be as great as 2.0 and 3.0, respectively.

3. The ground current on a double line-to-ground fault may be 50 per cent greater than the maximum value of a single line-to-ground fault.

The authors stated further that the range of voltages and currents on actual systems is determined principally by the ratio of the zero-sequence impedance to the positive-sequence reactance. They considered the zero-sequence-impedance ratio as a convenient criterion in connection with system grounding, and suggested that the preferred value of this ratio is in the range of from 1 to 4.

"Simultaneous Faults on Three-Phase Systems" were most ably and mathematically discussed by Miss Edith Clarke of the General Electric Company. The author extended the method of symmetrical components to apply to a three-phase system during simultaneous faults at two or more points of the system, and developed a general equivalent circuit replacing (in the positive-phase diagram) two simultaneous faults involving any combination of the six conductors. Further applications of the general method were discussed, and numerous typical cases were worked out in detail by the author, who stated that the methods and formulas given in her paper were developed in answer to such questions as:

1. Which is the more severe shock to a system, a double line-to-ground fault in one circuit or two single line-to-ground faults occurring simultaneously on two separate circuits?

2. Do simultaneous double line-to-ground faults which involve the same phases (*a* and *b*) on two circuits result in more, or less ground current than do faults which involve phases *a* and *b* on one circuit and phases *b* and *c* on the other?

Industrial Power Applications

Power usage, particularly as it affects power supply for large industrial establishments, was the central theme around which was built an important program for a joint session with the Association of Iron and Steel Electrical Engineers, and sponsored by that organization. Many significant phases of some of the more important problems arising from heavy-duty electric power interconnections between large industrials and the electric utilities were treated in the light of both engineering and economics by the several papers and by most of the large number of prepared discussions presented at the session. Perhaps the most vital single point brought out in the entire session was the fact that such interconnections, whether for one-way power supply or for the interchange of power between utilities and industrials, must show definite advantages and profits to both parties if such contacts are to remain in force for any length of time.

F. O. Schnure, of the Bethlehem Steel Company, outlined the three interconnection plans now in common practise as:

1. Where the utility furnishes all the power used by the industrial.

2. Where the utility furnishes peak power for the industrial with the latter supplying its own base load.

3. Where the utility furnishes the base load for the industrial, with the latter supplying its own peak power.

The author gave as a fourth possibility, that in which the utility purchases from the industrial surplus power, and stated that in his opinion the greatest economies for each party are to be found in the potentialities of interchange.

Operating experiences arising from the interconnection between the Duquesne Light Company and the Davison Coke & Iron Company, Pittsburgh, were given in a paper jointly prepared by G. E. Dignan, chief engineer of the Davison Coke & Iron Company, and R. I. Kirk, Duquesne Light Company.

Under the title "Absorption of By-Product Power," A. Hoefle of the Toledo

(Ohio) Edison Company, and W. T. Woodmany, of the Interlake Iron Corp., said in part:

> Complete and economic utilization of by-product is an end much to be desired in modern industry. Studies that have been made with reference to such an end have frequently revealed promising opportunities for cooperation between manufacturing plants and electric utilities. Some combined arrangement often will prove to be of economic benefit to both parties.
>
> The basic idea in a coordination scheme lies in the construction of efficient stations to operate at a good load factor by feeding into the utilities' systems whenever the manufacturers' demands for steam or by-product power drop off. Some of the methods of accomplishing this result are:
>
> 1. Use in the utility's plant of industrial by-products representing excess energy.
> 2. Sale of exhaust steam supplied by a central station's generating plant to a manufacturing establishment for process purposes.
> 3. Transfer of excess power generated in the manufacturer's generating plant to a utility system.
> 4. A joint arrangement in which manufacturer and utility own and operate a generating station and share the fixed and variable costs in proportion to benefits derived.

The authors gave examples upon which they based their conclusions.

A detailed discussion of some of the many problems entering into the question of electric power distribution within a large industrial establishment was given in paper prepared jointly by R. D. Abbiss of the Carnegie Steel Company, and D. C. West of the Westinghouse company.

The application of electrically-heated annealing furnaces for steel and other industries was described quite completely by J. C. Woodson of the Westinghouse company. After describing present practises and considering current operating experiences with the equipment in question, the author offered the following predictions as to the future:

> 1. A rapid and extensive expansion of electric annealing to wire strip and sheet mills generally to meet economic limitations and competitive costs.
> 2. The use of artificial furnace atmospheres to secure special and better results in fabricating and manufacturing processes.
> 3. There will be developed more of the large continuous electric furnaces for sheet annealing and normalizing, and with artificial atmospheres.
> 4. An extensive development and application of the principles of inductive heating to numerous heat-treating processes now considered unsuitable.

"A Modern Electrified Dairy Plant" described in a paper prepared jointly by A. J. Dreux of the Rieck-McJunkin Dairy Company, Pittsburgh, and H. C. Brunner of the Westinghouse company reflected another important application of electrical equipment. This paper is presented essentially in full elsewhere in this issue.

Power Supply For Communication Systems

In describing "Automatic Power Plants for Telephone Offices," R. L. Young, American Telephone and Telegraph Company, and R. L. Lunsford, Bell Telephone Laboratories, laid particular stress upon the exceptionally high degree of reliability in electric power supply that is essential for a telephone system. They described in detail unit-type power plants that have been developed for telephone offices, and mentioned the fact that the operating reliability record of modern equipment of this type is 99.9996 per cent.

A description of similar equipment developed for telegraph service was presented by E. W. Griffith of the Western Union Telegraph Company, in his paper "Telegraph Power Plants." The author traced the development of telegraph power plants from the era of the gravity battery down to the present combination of automatic equipment and storage battery.

Radio communication came in for its share of the discussion with a description presented by R. L. Davis of the Westinghouse company covering the power equipment at the new high-powered KDKA broadcasting station, and a lucid description of "Recent Developments in the Operation of Overseas Radio Telephone Service," presented by F. A. Cowan, of the American Telegraph and Telephone Company.

Students Active at Pittsburgh Meeting

At the district conference on student activities held March 12, 1931, in conjunction with the Pittsburgh meeting of the Middle Eastern District, each of the first two subjects was presented by two speakers, one representing industry and one representing the student point of view:

SUMMER EMPLOYMENT FOR ENGINEERING STUDENTS
- W. D. Bruce, chairman, University of Pennsylvania Branch, and
- O. W. Eshbach, Personnel Department, American Telephone & Telegraph Company.

QUALIFICATIONS LOOKED FOR IN A CADET ENGINEER
- Harmon Shively, chairman, University of Akron Branch, and
- E. B. Roberts, Educational Dept., Westinghouse Electric & Mfg. Co.

These topics were discussed by many present, and the following resolution was adopted:

Be it resolved that:

1. In view of the continued industrial depression with the resultant inability of industry to absorb the 1931 graduates, the technical colleges in the Middle Eastern District be requested to present to the senior classes the desirability of continuing their educational program; and furthermore that the college authorities be requested to seriously consider extending as much assistance as possible to students capable of profiting by this program.

2. The Chairman of this Committee be charged with the duty of forwarding this resolution to the college governing boards in the Middle Eastern District.

The third topic, "Has the Student Branch any Responsibilities to Freshmen and Sophomores?", was presented by C. L. Lucal, incoming chairman of the Ohio State University Branch, and W. J. Lattin, incoming chairman of the Case School of Applied Science Branch.

Professor J. T. Walther, counselor, University of Akron Branch, and vice-chairman and secretary of the district committee on student activities, presented a comprehensive report on the Branch activities in the district during the present academic year. This was followed by brief reports by several speakers giving additional information concerning the meetings of certain Branches.

Eleven of the eighteen Branches in the district were represented by their counselors and chairmen, and two others by the chairmen only.

LUNCHEONS

Prior to the student conference a joint luncheon meeting of the counselors and chairmen was held. At this Professor Morland King presided and brief addresses were given by E. C. Stone, vice president of the Middle Eastern District; F. L. Hutchinson, national secretary; and Henry H. Henline, assistant national secretary.

Vice-president Stone stated that the fundamental purpose of the Branches is to make better electrical engineers. He emphasized the importance of contacts between students and electrical engineers, and the benefits to be derived by students from the preparation, presentation, and discussion of papers. Mr. Hutchinson and Mr. Henline also spoke of the benefits available to students who participate in Branch activities. Mr. Henline gave a brief summary showing the great increase in student participation during recent years.

Separate luncheons were held March 13 for the counselors and for the Branch chairmen. At the Counselors' luncheon, it was decided that the next district conference on student activities will be held in the spring of 1932 in conjunction with the annual student convention of the schools in and near Philadelphia.

Professor J. T. Walther, counselor of the University of Akron Branch, was elected chairman of the district committee on student activities; Professor Lewis Fussell, counselor of the Swarthmore College Branch, was elected vice-chairman and secretary, both to take office August 1, 1931.

Directors Meet at Pittsburgh Gathering

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the William Penn Hotel, Pittsburgh, Pa., Thursday, March 12, 1931, during the Middle Eastern District meeting. Present were:—

President: W. S. Lee, Charlotte, N. C.—Past-president: R. F. Schuchardt, Chicago, Ill.—vice-presidents: Herbert S. Evans, Boulder, Colo.; W. S. Rodman, Charlottesville, Va.; E. C. Stone, Pittsburgh, Pa.; C. E. Sisson, Toronto, Ont.; G. C. Shaad, Lawrence, Kans.; H. P. Charlesworth, New York, N. Y.—directors: F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, A. E. Knowlton, New York, N. Y.—National Treasurer W. I. Slichter, and National Secretary F. L. Hutchinson, New York, N. Y.

Ratifications

Minutes of the directors' meeting of January 28, 1931, were approved.

A report of a meeting of the board of examiners held February 18, was presented and approved. Upon its recommendation the following elections were made of applications pending: 290 Associates; 13 Members; one Fellow. Transfers: 40 to grade of Member, and six to grade of Fellow.

In accordance with Sec. 22 of the constitution, S. L. Foster, E. E. Keller, and Wm. Lispenard Robb were exempted from future dues, and their names added to the list of "Members for Life."

The finance committee's approval of February bills amounting to $31,161.18, ratified. Decision was made to accept the invitation of the Cleveland Section and hold the 1932 summer convention at Cleveland, Ohio.

The board confirmed the president's appointment of the following committee of tellers to canvass and report upon ballot of election for Institute officers: P. C. Jones (chairman), Henry Kurtz, E. J. O'Connell, Hugh L. Smith, W. Y. Vedder, E. Volckmann, and J. T. Wells.

L. A. Ferguson was reappointed the Institute's representative on the Commission of Washington Award.

For appointment by the president of the National Academy of Sciences, H. P. Charlesworth was nominated as a representative of the Institute on the Division of Engineering and Industrial Research of the National Research Council, to succeed Dr. F. B. Jewett, whose term expires July 1, 1931, reappointment denied.

An invitation for September 21-25, 1931 from the Royal Institution of Great Britain to send a delegate to centenary celebration of Michael Faraday's discovery of electromagnetic induction was accepted, and the president empowered to appoint delegate and alternate.

Invitation was accepted to send a delegate to the celebration October 1-2, 1931, at the University of Cambridge, England, commemorating the birth of James Clerk Maxwell. The board also accepted invitation to be represented at the inauguration of President Chase, University of Illinois, May 1, 1931.

Resolution was adopted expressing the board's appreciation of various Pittsburgh meeting committees, in their excellent arrangements for the meeting and the effective manner in which plans were carried out.

Other matters were discussed, reference to which may be found in this and future issues of Electrical Engineering.

◆ ◆ ◆

Some Winter Convention Discussions are Summarized—Part II

A SUMMARY of some of the many discussions presented at the last five sessions of the 1931 winter convention is given herewith. A similar summary covering some of the discussions presented at the first four sessions of the convention was given on pp. 226-228 of Electrical Engineering for March 1931. Only discussions submitted in writing in accordance with A. I. E. E. rules governing it is summarized; complete discussion together with all papers so approved will be published in the Transactions. A list of papers presented was published in the January issue of Electrical Engineering, pp. 52-53.

Industrial Power Applications

Electron Tubes

H. S. Phelps discussed the use of a photoelectric switch for control of street-lighting circuits. An operating test of this device has disclosed a close approximation to the municipal schedule in effect and it has extended both the night and morning scheduled lighting period on cloudy or stormy days.

J. V. Breisky in his discussion classified the various types of tubes in general, and in particular the family of grid-controlled gas-filled tubes which he subdivided into three groups; cold-cathode tubes, hot-cathode tubes, and tubes employing a pool of mercury for a cathode. The characteristics of each class were described. In conclusion Mr. Breisky predicted that during the next few years a tremendous increase in this activity would take place, particularly when the larger tubes become standardized and are generally available.

C. R. Sharp cited an important application of photoelectric cells and electron tubes; namely, the photometry of incandescent lamps. He explained that the caesium cell has red sensitivity and is applicable for photometric purposes when the color between the lamps to be measured lies within the ordinary range of commercial lamps.

Automatic Regulators

In connection with discussion of this subject, S. Minneci described a system of automatic control for load-ratio control wherein a contact-making voltmeter is used as the master element. The control circuit is arranged similarly to that used with induction voltage regulators except that an adjustable time delay relay is inserted between the contact-making voltmeter and the motor-reversing contactor at the operating mechanism.

R. G. Standerwick discussed the performance of hydraulic regulators on turbine installations. Charts were shown illustrating the regulation of a 10,000-kw. speed-regulated turbine tied in with a second machine of 6,000 kw. capacity and operating over a wide fluctuation of electrical load.

Plant Distribution Systems

G. S. Merrill in his discussion of the section of the paper dealing with general-purpose indoor lighting pointed out that interest, taxes, depreciation, and the cost of electrical losses, are elements in the cost of producing light that should be taken into account in determining how the maximum amount of light per dollar in a new installation can be obtained. For the case in the paper where energy costs 1½c. per kw-hr. lamps operated at normal voltage will produce light at a unit cost about 2 per cent lower than if they were operated 5 volts under their labeled voltage.

A. B. Smedley discussed the cable and wire phases of the subject with particular reference to non-metallic, sheathed, underground cables. He pointed out that cable manufacturers have done much development work in perfecting the nonmetallic materials and compounds. Particular attention has been directed toward the possible elimination of materials of high-thermal resistivity and the tensile strength has been greatly increased without sacrificing flexibility.

SPECIAL SYNCHRONOUS MOTORS

Fraser Jeffrey in discussion of the subject pointed out that notwithstanding the high cost of the so called synchronous induction motor and its use being restricted principally to high-speed drives, such machines are being successfully applied to low-speed high-inertia drives at costs competitive to other modified types of salient-pole machines.

F. K. Brainard in his discussion of the subject made comparisons between induction motors and synchronous motors within the various speed ranges. The comparison is usually favorable to the synchronous motor up to speeds of 1,200 r. p. m. although it depends largely upon the value of reactive kva. in the particular installation.

Transportation Session Discussion

SUBURBAN ELECTRIFICATION

H. M. Trueblood discussed the paper "Lackawanna Suburban Electrification" from the standpoint of inductive coordination because this is the first electrification in the United States using rectifiers as the sole source of propulsion power; the contact-wire voltage is 3,000 volts. He pointed out that the results of field tests conducted under severe conditions indicated that the Bell System plant which is located in close proximity would experience little or no difficulty from induction or ground potentials.

One of the points commented upon by W. B. Potter in his discussion of the same paper was the method of putting the air intake for motor ventilation at the top of the car, thereby eliminating much dirt and brake-shoe dust from the motors.

C. H. Lydall discussed the paper and described a 3,000-volt d-c. electrification in South Africa where at first considerable trouble was caused by lightning. Later, however, the trouble was eliminated entirely by the installation of high-speed circuit breakers on the feeders to the track.

H. F. Brown in discussing the subject "Motive Power for Suburban Electrification," indicated that the conclusions reached in Mr. Kerr's paper agreed more or less in all points enumerated with the results obtained by the New Haven Railroad during twenty or more years of a-c. operation of electric suburban traffic.

INCLINED-CATENARY CALCULATIONS

W. B. Potter discussed the subject and in his opinion the type of structure given in the paper does not provide for the same flexibility on curves as the chord system. The contact between the line and the collector is best assured by flexibility of the line.

H. F. Brown commented favorably upon the paper by saying that not only did it present a valuable addition to the meager literature existing on inclined-catenary design, but also it has simplified somewhat the calculations required both in the development of the shape factors, and in their application to the track alinement.

N. Litchfield in his discussion of the subject pointed out that the so called "curved" or "inclined" catenary was originated by the engineers of the New Haven Railroad in 1909. To accommodate longer spans with sharp curves, particularly transition curves, the original method of calculation was modified in 1913-14 by Messrs. H. S. Richmond and Philip Goldstone, and has become practically the standard method in general use. In conclusion it was stated that Mr. Picken's paper is well worked out and should be of interest to all catenary designers.

H. S. Richmond discussed the subject and stated that in his opinion equation (33) of the paper is not significant because the *U*-curve practically approximates the circle and most track curves are not actually so uniform.

J. B. Colley in his discussion of the subject outlined a method of calculation for the transition curve which he believed is shorter than the method given in the paper and although not so exact, seems to be within the bounds of practicability.

H. F. Brown discussed "Design of Catenary System for Cleveland Union Terminal." He drew attention to the temperature movements of the center of 250- or 300-ft. spans where a bronze messenger is used instead of steel messengers. He also commented on the use of chains for suspension and pull-off members, which he pointed out are subject to vibration, weather, and corrosion, and in the course of a few years are liable to wear very thin. In his opinion such parts should be reduced to a minimum.

Electric Welding Session Discussion

S. Dushman discussed "Arcs Between Metal Electrodes" stating that one of the most important results to follow from this investigation is the conclusion that the transition from the glow to the arc (or vice versa) is governed more by the current density at the cathode than by the temperature of the latter. He discussed the conclusions from the point of prevalent theories on the phenomena occurring in the transition from glow to arc and on the origin of electrons at the cathode of an arc discharge.

C. G. Found's discussion of the same subject was presented by Dr. Dushman. He commented on the paper as being a valuable contribution to the study not only of arcs but also of general discharges in gases, particularly the transition stages from the normal to the abnormal glow and from the abnormal glow to the arc.

J. Slepian discussed the paper raising the questions, (1) may not the transition states observed by the authors be only apparently equilibrium transition states? (2) May they not consist of very rapid alternations between the glow states and the high-current density arc state? He called attention to the fact that these alternations might take place with such high frequency as to escape detection on the oscillograph used by the authors.

A. Churchward discussed "An Improved Arc-Welding Generator" stating that early in 1924 he had used the transformer reactor on a self-excited drooping welding generator, and his tests confirmed the results in the paper.

D. W. Ver Planck discussed "The Neutralized Welder" and commented on the fact that the paper demonstrated that the steady-state and some of the transient characteristics of welding generators can be determined analytically. He was of the opinion that the equivalent circuit method which leads to the same results is considerably simpler than the method described in the paper.

D. W. Ver Planck also discussed "A System for D-C. Arc Welding." He presented a method of analysis which showed to what particular quality of the machine each part of the transient was due, and would suggest to the designer the way in which any part of the transient might be emphasized or suppressed. The current transient following a short circuit can also be handled in a similar fashion, though with somewhat less ease.

Research Session Discussion

H. H. Race discussed "Conductivity of Insulating Oils—II." He commented on the paper pointing out that the author deserves considerable credit for developing sensitive apparatus for determining short-time d-c. characteristics. The conclusions, if correct, will have a far-reaching effect upon the development of the theory of liquid dielectrics. Several reasons why the initial exponential portion might be due to an oscillographic error rather than a characteristic of the oil were given by H. H. Race in his discussion. He also inquired as to the meaning of "dielectric absorption" in connection with the results.

CABLE OILS

J. B. Whitehead discussed "Some Electrical Characteristics of Cable Oils." He pointed out that no quantitative relation had been found heretofore between the one-minute or long-time d-c. conductivity and the actual values of dielectric loss at various frequencies. He believed Dr. Race went a little too far in the suggestion in his paper that the one-minute d-c. conductivity is a sufficient indication of the a-c. properties of the oil.

One of the points discussed by W. B. Kouwenhoven in his discussion of "Electrical Characteristics of Cable Oils" was the curve in Fig. 6 showing the variation of resistivity of oil with temperature. He gave data on resistivities of two oils at 1,500 volts, taken at various temperatures at a voltage gradient of 25 volts per mil made at four mil-seconds to 40 minutes after the application of voltage. When these data are plotted on semi-log paper the 40-minute values fall on straight lines of a slightly greater slope than those given in the paper. The four mil-second values did not give a straight line relation when plotted as in Fig. 6. The resistance of oil varies not only with temperature but also with the time after the application of voltage.

In connection with the discussion of "The Conductivity of Insulating Oils," S. K. Waldorf replied to H. H. Race's questions concerning the oscillograms; he explained that the response of the apparatus to d-c. impulses was recorded and that it was shown that the oscillograph vibrator used was over-damped rather than under-damped and it did not over-travel. He also explained that deflections were measured to a tenth of a millimeter which on oscillograms having the smaller deflections gives a current value accurate to within about 5 per cent or better. With larger deflections, the accuracy of such measurements is of the order of 1 per cent and better.

C. L. Dawes discussed "Fundamental Properties of Impregnated Paper." He discussed the so called *V* or *U* curves of the power loss in impregnated-paper insulation as a function of temperature and pointed out the value of the paper in giving a definite explanation, (substantiated by experiment) for these curves.

TRAFFIC CONTROL BY LIGHT BEAMS

F. Hamburger, Jr. discussed this subject and in his opinion a twelve-second green light for minor street traffic where traffic is light was too long. He asked if it was not possible with the control described in the paper to set the minor street green for six seconds and provide a step-up feature or time extension to permit a longer minor street green in the event of several cars following one another?

COMMUTATION IN HYDROGEN

T. T. Hambleton's discussion of this subject was read by Mr. Linville. He reported results of tests made on a 3,000-kw., 10,000-ampere, 60-cycle, 300-volt, converter which was operated in a gas-tight enclosure of hydrogen. The results showed a reduction in windage loss amounting to approximately 25 kw. and an increased cooling efficient. The rating of the converter when operating in hydrogen could be increased 25 or 30 per cent with approximately the same ultimate temperatures in the current-carrying parts as were reached at the lower rating when operating in air.

NON-LINEAR CIRCUITS

V. Karapetoff discussed this subject and mathematically analyzed his conception of one of the series circuit conditions.

E. Weber discussed the subject and gave a fundamental analysis of the distortions shown in the waves of the current and voltage drops across the reactor and capacitance. His fundamental analysis showed that this phenomenon is quite in accord with ordinary series resonance of the double-energy linear circuit, and differs only in that it exists for only a small part of the period.

Electrical Machinery Session Discussion

C. R. Boothby discussed "Induction Motor Slot Combinations" and brought out that while appreciable "hooks" are indicated in many of the speed-torque curves shown in the paper, for most commercial applications these would not be unsatisfactory. Combinations which are noisy at low speeds often are very quiet at normal operating speeds.

H. C. Specht, in his discussion of this same subject, (read by C. R. Boothby) doubted if the theory of revolving permeances was any more useful in simplifying the problem of noise and cusps in the speed-torque curves of induction motors. He commented upon a number of the rules given in the paper and believed that the reader would profit a great deal more from the valuable data given if it were clearly shown how the ten rules were derived from the mathematical work.

L. A. Doggett also discussed the paper and expressed hope that the author would go a step farther and give tables recommending the number of slots for the more common cases. Upon trying to apply the rules given by the author to the case of a two-pole, three-phase machine it was found that all possible values of rotor-slot numbers were eliminated by one or more of the ten rules.

THE PULLING INTO STEP OF A SALIENT-POLE SYNCHRONOUS MOTOR

D. W. McLenegan and I. A. Terry discussed this subject and commented on the value of the M. I. T. integraph in solving problems which are very difficult to treat analytically. They described tests on a 75-hp., three-phase, 900-r. p. m., 0.80-power factor, synchronous motor to determine the effect of the field time constant upon the pull-in characteristics. Results of these tests show that due to ideal timing of the instant at which the field is applied a motor may pull into step from a slip greater than that indicated by formula (5) in the paper.

V. Bush discussed the paper with particular reference to the integraph and the stroboscope. He explained that a new integraph was now under construction which would be capable of solving total differential equations of very considerable complexity and with much better precision than was possible with the present machine. He also commented on the new stroboscope and the very large light intensities produced. He explained that Mr. Edgerton used a stroboscope which had a period of illumination of only about 10 microseconds occurring once each cycle and yet was able to obtain sufficient light for photography.

HEAT LOSSES IN LARGE TURBINE GENERATORS

C. J. Fechheimer discussed this subject and commented on the complexities of the problem. He pointed out that by modifying the boundary conditions the author has simplified his solution and has put it into workable form by substituting equivalent electrical circuits for the heat circuits.

K. K. Palueff discussed the paper and described how a short-circuit table such as is used for the analysis of short-circuit characteristics of transmission systems could be employed to solve thermal problems similar to those mentioned by the author.

One of the points discussed by D. S. Snell in his discussion of the subject was the assumption made in the paper that the plane of division of radial heat flow in the tooth region is at the bottom of the slot. He pointed out that while this assumption is justifiable for turbine generators with radial ventilating ducts in both stator and rotor, it might give temperatures very much higher than the actual for turbine generator rotors of the solid-forged type with ventilating channels below the coil slots.

THE NON-RESONATING AUTO TRANSFORMER

F. J. Vogel discussed this subject and one of the points which he brought out was that experience in the design of transformers has indicated always that practically the entire surge voltage is across the series part of the winding whether or not the low-voltage line is connected; and good insulation practise has been established on this basis. He also discussed interleaved windings and submitted a figure which shows the initial distribution and oscillations within the winding. All the stress is distributed over the series part of the winding and high voltages do not prevail at points of discontinuity as claimed in the paper.

◆ ◆ ◆

Rochester Meeting Features Noise Abatement and Lightning Studies

An attractive program consisting of four technical sessions and entertainment with a special program for the ladies and a number of interesting inspection trips has been arranged by the Local Committee for the meeting of the North Eastern District of the A. I. E. E. to be held at Rochester, April 29 to May 2. Headquarters will be at the Sagamore Hotel.

Because of its location Rochester is readily accessible from all points in the East and is possessed of scenic beauty of unusual interest. It is particularly noted for its fine residential sections, being known throughout the Empire State as the "city of homes." Also of importance is its manufacturing center; several of the large plants located in the city will be open for inspection to members and their guests.

TECHNICAL SESSIONS

The first two technical sessions are on selected subjects; the third will present a symposium on noise, and the fourth session, a symposium on lightning. The selected subjects offer a variety of papers, some on cables, others on special transformers, cusps in the speed-torque curves of induction motors, and equivalent circuits of imperfect condensers.

JOINT SESSION ON NOISE ABATEMENT

With the object of outlining a broad and efficacious program on "noise investigation" and in worthy conclusion of the morning session at which will be presented a symposium on "Noise in Electrical Machinery," a joint meeting will be held on the evening of April 30, 1931, at which the N. E. L. A., N. E. M. A., A. S. M. E. and A. I. E. E. will all be capably represented. The morning symposium will include methods of noise reduction, described by Westinghouse engineers, the manufacturers' view of the noise problem summarized by Prof. B. F. Bailey, University of Michigan, chairman of N. E. M. A. committee on noise, and a paper by E. A. Bishop of the Commonwealth Edison Company, Chicago, on the mitigation of noise in substations.

ENTERTAINMENT

An informal reception, with dancing and card playing will be held on Wednesday evening. The following evening will be devoted to an inspection of the Eastman Theater and Eastman School of Music. The theater is reputed to be one of the most beautiful in the country, and the School of Music, in the short time it has been operating, has achieved international distinction. The theater will offer a performance of current attraction.

THE MEETING DINNER

A dinner will be held on Friday evening, when H. H. Sullivan, past-president of the Rochester Engineering Society, will act as toastmaster, and Professor Walter King Stone of the College of Architecture, Cornell University, will give an address on "What the Artist May Contribute." Entertainment and dancing will follow the presentation of district prizes.

LADIES' ENTERTAINMENT

In addition to the foregoing entertainment, the Ladies' Committee has arranged a special program of luncheons, a luncheon and bridge at the home of Mrs. H. H. Sullivan, and sightseeing trips to some of Rochester's most scenic points.

LADIES' PROGRAM

WEDNESDAY, APRIL 29

9:00 a. m. Registration at meeting headquarters
12:30 p. m. Luncheon at Sagamore Hotel
2:00 p. m. Sightseeing trip
8:00 p. m. Reception at Sagamore Hotel

THURSDAY, APRIL 30

Morning free for shopping
1:00 p. m. Luncheon and bridge at the home of Mrs. H. H. Sullivan
7:30 p. m. Inspection of Eastman Theater and Eastman School of Music, including a performance of current attraction

FRIDAY, MAY 1

12:00 m. Luncheon
2:00 p. m. Sightseeing trip
7:00 p. m. Dinner

INSPECTION TRIPS

A program of interesting and profitable inspection trips to large and well-known manufacturing plants in Rochester also to the utility interests and the University of Rochester has been scheduled for Thursday afternoon and Saturday morning. In addition, several inspection trips for the students have been arranged for Friday afternoon at 2:00 p. m.

HOTEL RESERVATIONS

Reservations at the various hotels are available by writing to O. L. Angevine, executive secretary of the Rochester Engineering Society, 111 East Avenue, Rochester, N. Y. A form for this purpose will be mailed with announcement to the membership; also a list of the rates for the various hotels.

COMMITTEES

The personnel of the district meeting committee consists of: I. E. Moultrop, vice-president, North Eastern District, chairman; A. C. Stevens, secretary-treasurer, North Eastern District; J. N. Alberti; C. W. Henderson; E. C. Karker; C. H. Kline; H. J. Klumb (chairman of the local executive committee); R. G. Warner; and F. C. Young. The officers of the general committee are: E. C. Karker, chairman; F. C. Young, secretary-treasurer; H. S. Collins, assistant secretary-treasurer. The following are chairmen of the various subcommittees: O. L. Angevine, hotels and registration; V. M. Graham, inspection trips and transportation; O. L. Angevine, publicity; J. G. Carritt, entertainment and banquet; W. H. Reichard, sports; H. J. Klumb, finance; Mrs. O. L. Angevine, ladies' entertainment.

Tentative Program

(Eastern Standard Time)

Wednesday, April 29

9:00 a. m. Registration
10:00 a. m. Welcoming addresses:

Stephen B. Story, City Manager

Virgil M. Palmer, Rochester Engineering Society

10:20 a. m. Session on Selected Subjects

TEMPERATURES IN ELECTRIC POWER CABLES UNDER VARIABLE LOADING, E. A. Church, Edison Electric Illuminating Company of Boston.

PROXIMITY EFFECT IN CABLE SHEATHS, H. B. Dwight, Massachusetts Institute of Technology

CUSPS IN THE SPEED-TORQUE CURVES OF INDUCTION MOTOR DUE TO SPACE HARMONICS, P. H. Trickey, Westinghouse Electric & Mfg. Co.

LOSSES IN TRANSFORMERS FOR USE WITH MERCURY ARC RECTIFIERS, E. V. DeBlieux, General Electric Co.

2:00 p. m. Session on Selected Subjects

Theory of Thermal Breakdown of Solid Dielectrics, P. H. Moon, Massachusetts Institute of Technology

The Three-Circuit Transformer, C. F. Estwick, General Railway Signal Co.

Core-Loss Measurements at High-Flux Density, B. M. Smith and C. Concordia, General Electric Co.

Equivalent Circuits of Imperfect Condensers, C. L. Dawes and W. M. Goodhue, Harvard University

8:00 p. m. Informal reception—dancing and cards

Thursday, April 30

9:00 a. m. Symposium on Noise

The Measurement of Noise in Electrical Machinery, B. F. Bailey, University of Michigan

An Indicating Meter for the Measurement and Analysis of Noise, T. G. Castner, Bell Telephone Laboratories, E. Dietze and R. S. Tucker, American Telephone and Telegraph Co., and G. T. Stanton, Electrical Research Products, Inc.

The Measurement of Machinery Noise, H. B. Marvin, General Electric Co.

Induction Regulator Noise, J. P. Foltz and W. B. Shirk, Westinghouse Electric & Mfg. Co.

Magnetic Noise in Synchronous Machines, Q. Graham, P. Milliken, and S. Beckwith, Westinghouse Electric & Mfg. Co.

Elastic Supports for Isolating Rotating Machinery, E. H. Hull and W. C. Stewart, General Electric Co.

Noise Mitigation in Substations, E. A. Bishop, Commonwealth Edison Co.

12:00 m. District Executive Committee luncheon

2:00 p. m. Inspection trips:

Bausch and Lomb Optical Company
Stromberg-Carlson Telephone Mfg. Co.
Monroe Telephone Exchange
Kodak Park Works, Eastman Kodak Co.

2:00 p. m. Symposium on Noise—*continued*

Demonstration of Noise Measurement Apparatus

6:15 p. m. Joint Dinner Meeting of representatives of National Noise Study Committees of N.E.L.A., N.E.M.A., A.S.M.E., A.I.E.E. and other organization

7:30 p. m. Inspection of Eastman Theater and Eastman School of Music, including a performance

Friday, May 1

9:00 a. m. Student technical session

12:00 m. Student luncheon

2:00 p. m. Student inspection trips:

University of Rochester
Eastman Kodak Co.
Station 33, Rochester Gas & Electric Corp.

2:00 p. m. Symposium on Lightning

Lightning, F. W. Peek, Jr., General Electric Co.

Lightning Discharges and Line Protective Measures, R. N. Conwell, Public Service Electric & Gas Co., and C. L. Fortescue, Westinghouse Electric & Mfg. Co.

Lightning Investigation on the 220-Kv. System of the Pennsylvania Power and Light Co., Edgar Bell and A. L. Price, Pennsylvania Power and Light Co.

1930 Lightning Investigations on the Transmission System of the American Gas and Electric Company, Philip Sporn, American Gas and Electric Co., and W. L. Lloyd, Jr., General Electric Co.

Lightning Investigation on the Appalachian Electric Power Company's Transmission System, I. W. Gross, American Gas and Electric Co., and J. H. Cox, Westinghouse Electric & Mfg. Co.

Experimental Studies in the Propagation of Lightning Surges on Transmission Lines, O. Brune and J. R. Eaton, Consumers Power Co.

Lightning Investigation on Transmission Lines—II, W. W. Lewis and C. M. Foust, General Electric Co.

6:30 p. m. Dinner; lecture, presentation of district prizes, and entertainment with dancing.

Saturday, May 2

8:30 a. m. Symposium on Lightning—*continued*

9:00 a. m. Inspection trips:

General Railway Signal Company
Station 9 of Rochester Gas and Electric Corp.
Coke Plant of Rochester Gas and Electric Corp.
University of Rochester
Niagara Falls

1931 Year-Book Now Available

The Institute's year-book for 1931, containing as usual a complete listing arranged both alphabetically and geographically of names and addresses of all members (correct to January 1, 1931), a copy of the by-laws and constitution, list of Institute officers and committees, as well as other information of interest in Institute activities, is now available for distribution.

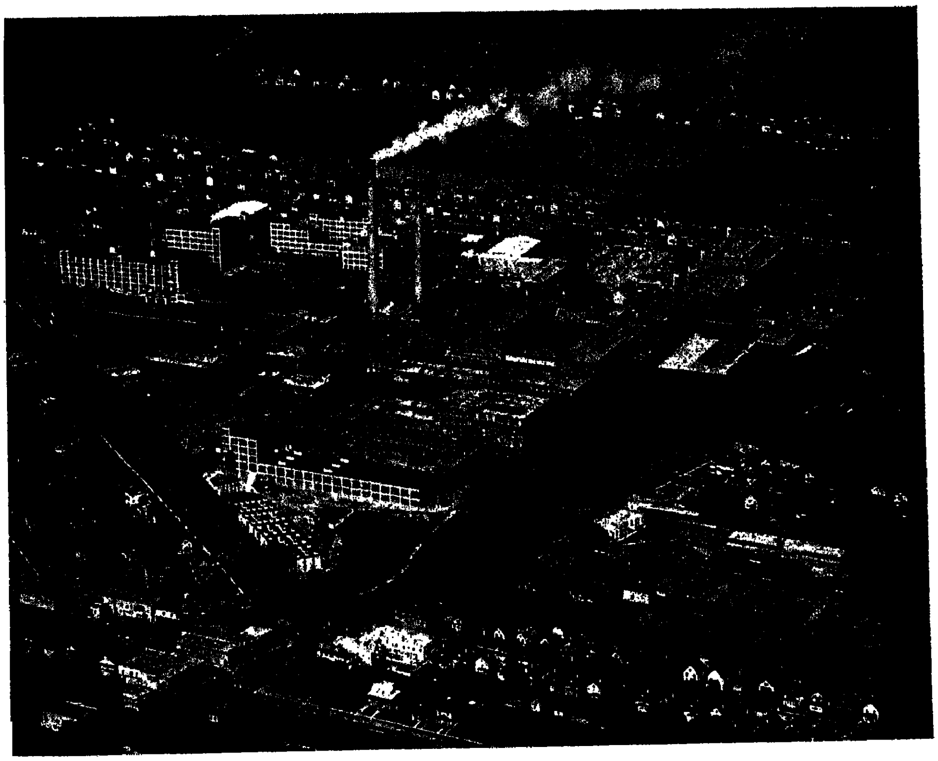
On page 127 there will be found a paragraph requesting the earnest cooperation of all members to prevent the use of this year-book for advertising or circularizing purposes. Any such action must be considered as outside of its field of application, and as absolutely prohibited.

◆

Chemical Exposition To be Held in New York

The thirteenth exposition of Chemical Industries will be held at the Grand Central Palace, New York, during the week May 4-9, 1931.

The biennial exposition regularly includes not only exhibits from all of the forty or more industries classified as chemical, but also those from many others producing material or equipment used in chemical industries. Thus is offered an opportunity for studying a large array of equipment, and for comparing competitive products side by side.



Kodak Park—headquarters of the Eastman Kodak Co., one of Rochester's many nationally known industries

Plan Your Vacation to Include the Lake Tahoe Convention

AN OPPORTUNITY for a delightful and useful summer trip is afforded by the choice of Lake Tahoe, California, as the scene of the Pacific Coast convention to be held August 25-29, 1931. Lake Tahoe is strategically situated—on a transcontinental main-line railroad, a mile high in the famous Sierra Nevada Mountains—and provides facilities that will make this a highly successful family convention. And the high-caliber technical program that rapidly is being completed will well justify an extra effort to attend.

◆

All Engineers Welcome At International Congress, England

Anyone expecting to attend the 1931 International Illumination Congress opening at London September 2, 1931 (detail of which was published in the January Electrical Engineering, p. 59), should notify G. H. Stickney, secretary of the U. S. National Committee, Nela Park, Cleveland, Ohio.

Every endeavor is being made to keep the cost of travel as reasonable as possible; the conference is open to all interested in illumination in any of its branches, and the registration fee of £2 includes a copy of the proceedings of the congress; ladies exempt from all fees. A reception will be tendered by the civic authorities of each city in which the congress holds session.

◆

A. S. A. Releases Refrigeration Safety Code

The American Standards Safety Code for Mechanical Refrigeration has just been published (February 1931) by the American Standards Association, 29 West 39th Street, New York, N. Y. The code which is sponsored by the American Society of Refrigerating Engineers, was approved by the American Standards Association in October 1930, and already has been adopted in its entirety by several cities; still others are considering its adoption. It represents one of the most important instances of the precaution necessary to prevent improper installation or use of technical equipment, already being taken by industry instead of its waiting to be forced into such action by public demand.

The booklet containing the safety code contains complete but concise information about the code and its advantages. It has been prepared as a reference manual for the use of any person or organization interested in its general adoption and use and it provides thoroughly practical and adequate regulatory measures for safe installation, operation, and inspection of mechanical refrigeration systems or units.

◆

Washington Award Made to Ralph Modjeska

On February 25, 1931, before 360 members and guests of the five societies participating, Doctor Ralph Modjeska who in 1929 received the John Fritz Medal, highest American engineering award, had bestowed upon him the new honor of the Washington Award "for pre-eminent service in advancing human progress." Dr. Modjeska's history is too well known to require delineation here.

This award is administered by the Western Society of Engineers (Chicago) upon the recommendation of a commission representing the four founder societies; this year's ceremonies were at the Palmer House, Chicago, with Elmer T. Howson, chairman of the commission, presiding. Dr. Modjeska's acceptance was brief and was followed by a well-planned program at which Ralph Budd, president of the Great Northern Railway and principal speaker of the evening, gave an inspiring address upon the importance of the engineer's qualifying more fully to meet the economic problems bearing upon human progress.

Summer Convention At Asheville, N. C., June 22-26

The annual summer convention of the Institute will be held at Asheville, N. C., June 22-26, with headquarters at the Grove Park Inn.

Asheville, widely proclaimed by President Lee as the "land of the sky," is located in the highest part of the Blue Ridge Mountains, at an elevation of approximately 2,700 ft., and is counted one of the most scenic splendors of the South. Mt. Mitchell, rising to a height of 6,711 ft., and the highest peak east of the Rockies, is but a short distance away. The city's geographical location offers a splendid opportunity for members and their guests to visit such scenic points as Chimney Rock, Lake Lure, etc.

Seven technical sessions of broad scope and current interest have been scheduled tentatively as follows: automatic stations, symposium on system interconnection, cables, communication, instruments and measurements, electrical machinery, selected subjects, and research. The annual reports of technical committees, outlining advances in theory and practise of electrical activities in the various fields will also become available.

More complete details of this exceptional program will be announced in subsequent issues of Electrical Engineering.

◆

Two Important Meetings at Birmingham

Birmingham (Ala.) the "largest city for its age in the world" will be possessed of a double importance when The American Society of Mechanical Engineers holds its semi-annual meeting there April 20-23, 1931, followed by an overlapping meeting of the American Electrochemical Society April 23-25. Headquarters for both of these meetings will be the Hotel Tutwiler, ideally situated in the "city beautiful" which lies among the foothills of the Appalachian Mountain group, with Red Mountain, Shades Mountain, the Mountain Brook Country Club, and the Birmingham Country Club all close at hand.

A system of electrification has been built up covering the state from Muscle Shoals to Mobile; a part of the attractive program arranged for the A. S. M. E. meeting will be devoted to the inspection of important industrial plants with generous allowance of time to be spent on hydroelectric installations—the Alabama Power Company's installation at Martin Dam, a reservoir of 40,000 acres furnishing 3,000,000 kw. storage, and Jordan Dam, the maximum head of which is 91 ft. Also there will be an interesting railroad session, one on power, another on safety, and still another on the handling of materials and machine shop practise, besides others devoted to subjects of more purely mechanical interests, each however with its quota of well-selected and carefully prepared subjects.

◆

Astronomy and Electricity

As a fitting climax to one of the most successful years that the New York Section of the Institute has ever had, where the total attendance will exceed by 350 per cent that of the previous year, the officers of the Section have arranged an evening on "Astronomy and Electricity" to be held jointly with the New York Electrical Society in the Engineering Auditorium, 33 West 39th Street, New York, at 8:15 p. m. on Friday, April 24, 1931.

The speaker will be Dr. H. T. Stetson, director of the Perkins Observatory of Ohio Wesleyan University, Delaware, Ohio, which has the third largest telescope in the world. Dr. Stetson will outline clearly the results of recent investigation of the effects of solar activity on the earth's magnetism and on radio transmission. Sun spots and other astronomical phenomena will be dealt with in a manner understandable and entertaining to the engineer.

Preceding Dr. Stetson's talk, a description of the "Electrical Projection Planetarium" will be presented by Dr. Clyde Fisher of the American Museum of Natural History.

Both speakers are eminent in their respective fields and both talks will be profusely illustrated.

Annual Report Issued by United Engineering Trustees, Inc.

In calling attention to the availability of the annual report of United Engineering Trustees, Inc., a short historical outline may be of interest.

The United Engineering Trustees, Inc., which originally was called the United Engineering Society and then for a time Engineering Foundation, Inc., was incorporated in 1904 to administer the Engineering Societies Building, certain endowments, and other funds for its Founder Societies, the national societies of civil, mining, mechanical, and electrical engineers. Its objects—which are to maintain a free engineering library—to advance the engineering arts and sciences, to further research, are carried on through its three departments: The Engineering Societies Library, The Engineering Foundation, and the Administrative Department.

The three events of greatest significance in its history are the erection of the Engineering Societies Building at 29 West 39th Street, New York City (dedicated in 1907), the consolidation of the various society libraries in 1913 together with the establishment of the Library Endowment Fund by a gift from Dr. James Douglas of $100,000, and the creation of an engineering research foundation known as The Engineering Foundation, through the suggestion and generosity of Ambrose Swasey, whose gifts now total half a million dollars. The various funds over which the trustees now have supervision amount to $1,136,000.

In President Francis Lee Stuart's annual report for 1930 it is pointed out that the assets for which the corporation is responsible (real estate at cost, funds, and library as appraised) total $3,524,422.27. The development committee gathered data during the year on which to base an

SUMMARY OF 1930 FINANCIAL REPORT

Operation of Building		
Credit balance January 1, 1930		$12,290.66
Building revenue 1930	$133,170.65	
Building expenditures 1930	120,274.58	12,896.07
Total		$25,186.73
Annual payment to dep. and renewal fund	$12,000.00	
Reimbursement of general reserve fund	1,000.00	
Payment to reserve for future fire insurance	1,550.00	14,550.00
Credit balance December 31, 1930		$10,636.73
Operation of Library		
Maintenance revenue	$50,287.71	
Maintenance expenditures	48,046.69	
Credit balance for year 1930	2,241.02	
Credit balance from preceding years	3,447.93	
Total credit balance December 31, 1930		$ 5,688.95
Service bureau revenue	$21,559.89	
Service bureau expenditures and adjustments	20,842.18	
Credit balance for year 1930	717.71	
Credit balance from preceding years	4,016.25	
Total credit balance December 31, 1930		$ 4,733.96
Funds and Property		
Funds held by U. E. T. Inc., Dec. 31, 1930 (Book Value)		
Depreciation and renewal fund		283,734.79
General reserve fund		3,934.40
Engineering foundation fund		529,253.65
Henry R. Towne engineering fund		50,078.13
Library endowment fund		173,475.32
Edward Dean Adams fund		100,000.00
John Fritz Medal fund (Custodian)		3,500.00
Louvain Memorial fund		8,589.95
Total		$1,152,566.24
Real estate owned, cost to Dec. 31, 1930		1,987,793.92
Operating cash and petty cash		15,592.43
Accounts receivable		1,878.79
Value of library (as appraised for insurance)		358,544.00
Endowment committee loan receivable		1,700.00
Unexpired fire insurance premiums		3,297.09
Fire insurance fund (cash uninvested)		3,050.00
Total property which U. E. T. Inc. owns or holds		$3,524,422.47

estimate of the societies' needs for accommodations in the next ten years or more and a project for meeting those needs is under consideration. The Engineering Societies Building is reported in good condition but overcrowded.

In April, 1930 at the 50th anniversary of the American Society of Mechanical Engineers, a memorial tablet was placed in the entrance hall. The War Memorial to American Engineers in the Louvain Library continues to be of great interest to visitors to Belgium.

In passing to the summary of the financial report, it is worthy of note that all departments closed the year without deficits.

Engineering Foundation

Dielectric Research to Reveal Fundamental Properties

A study of the fundamental properties of dielectrics, a research conducted by Prof. J. B. Whitehead at The Johns Hopkins University, Baltimore, is part of a comprehensive program directed by the National Research Council's committee on electrical insulation.

During the year, the work on the research aided by Engineering Foundation has been mostly the design, construction, and installation of apparatus for exhaustive investigation of the dielectric properties of liquids, particularly insulating oils. The apparatus was successfully completed during 1930 and papers covering these researches are appearing from time to time in the publications of the A. I. E. E.

◆

Welding Research Aided by Foundation

At the request of the A. I. E. E. the Engineering Foundation is aiding an investigation of pure iron electrodes to obtain basic data of use to electric welders.

This research is being conducted by Prof. Gilbert E. Doan under an agreement between the Foundation and Lehigh University. It was undertaken in June 1930 and progress has been made in designing and installing special apparatus and in developing methods.

Standards

Specifications for Dry Cells and Batteries

American standard specifications for dry cells and batteries have been issued recently as Circular No. 390 of the Bureau of Standards. These specifications prepared by the Bureau with the cooperation of manufacturers and users are a revision of the American standard of Feb. 27, 1928. The revision has been carried out concurrently by a technical committee of the Federal Specifications Board and the sectional committee of the A. S. A.; the two specifications are identical in substance, differing only in arrangement. Copies of Circular No. 390 may be obtained from the Superintendent of Documents, Washington, D. C., at a price of 5 cents per copy.

◆

Weatherproof and Heat-Resisting Wire and Cable Specifications Approved

Two specifications developed by the sectional committee on insulated wires and cables came before the standards committee of the Institute on January 23, when they were approved by it; and subsequently by the board of directors on January 28, 1931. The specifications are as follows:

1. Weatherproof (weather-resisting) Wires and Cables: These specifications cover weatherproof wires and cables and the materials used for the braids and saturating compounds as applied to metallic conductors.

2. Heat-Resisting Wires and Cables: These cover the usual type of heat-resisting coating commonly known as "slow-burning," applied to metallic conductors for use in hot, dry locations where the standard insulating materials would not endure long or where the presence of large masses of inflammable materials would be objectionable.

Both of these specifications were developed by the committee acting under the procedure of the American Standards Association and the sponsorship of the A. I. E. E. and nine other bodies. They are now before A. S. A. for approval as American standards and upon the granting of such approval will be issued in pamphlet form by the Institute.

Specifications for Code Rubber Approved

A "Specification for Code Rubber Insulation for Wire and Cable for General Purposes" as developed by the sectional committee on insulated wires and cables, also was approved by the standards committee and subsequently (Jan. 28, 1931) by the board of directors. This specification will follow the same procedure as the two previously mentioned, and upon approval as an American standard will be issued by the Institute.

◆

Revised Report on Proposed Lightning Arrester Standards

The protective devices committee of the Institute has just reported on revision of the proposed "Standards for Lightning Arresters." The first report on this subject has been available since May 1928; the revision will be issued in pamphlet form replacing Report No. 28 of that date. Comments and criticisms are urgently requested and should be forwarded to Raymond Bailey, chairman A. I. E. E. protective devices committee, Philadelphia Electric Co., 900 Sansom St., Philadelphia, Pa. Copies of revised Report No. 28 may be had without charge by addressing H. E. Farrer, secretary standards committee, A. I. E. E., 33 West 39th St., New York, N. Y.

Personal

D. C. PRINCE has been appointed engineer of the switchgear department of the General Electric Company at Philadelphia. The appointment includes supervision of switchgear research activities at Schenectady. Mr. Prince has been with the General Electric since 1912, his work including the radio engineering department, the research laboratory and the switchgear department as research engineer. R. M. Spurck continues as assistant engineer with extended duties, and Chester Lichtenberg, assistant engineer since 1927, has been relieved of his duties to undertake a special assignment.

◆

E. O. SHREVE, assistant vice-president in charge of sales, General Electric Company, Schenectady, made a tour of its western offices last month, including those in Dallas, Houston, El Paso, Phoenix, Los Angeles, San Francisco, Portland, Seattle, Spokane, Salt Lake, and Denver. In his capacity as a director in the American Management Association, he spoke before the Iron and Steel Conference, California State Chamber of Commerce, at Del Monte, Calif., and was the feature speaker at a meeting of the San Francisco Electrical Development League.

◆

Hadley F. Freeman of Cleveland associating himself with G. M. Albrecht, former examiner in the United States Patent Office has opened offices under the company name of Freeman and Albrecht, Patent Attorneys, at 807 Mariner Tower, Milwaukee, Wisconsin. Mr. Freeman is a member of the firm of Smith and Freeman, Patent Attorneys, Cleveland, and of Freeman and Sweet, Patent Attorneys, Chicago; both will be represented by the new firm.

◆

H. C. Leonard, who was elected president of the Electrical League of El Paso (Texas) at a recent meeting, has been known to the electrical fraternity of El Paso for less than a year. He came to the western city last summer to take over the duties of general superintendent of the El Paso Electric Company, succeeding W. R. Bell, who was transferred to other Stone & Webster properties at Baton Rouge, La.

◆

Frank J. Airey, division manager of the General Electric Supply Corporation at Los Angeles, was elected chairman of the Pacific Division, National Electric Wholesalers' Association, at the annual meeting of the organization at Del Monte, Calif. He has been in the electrical merchandizing business more than 42 years, having occupied the various positions of salesman, sales manager, division manager and general manager.

◆

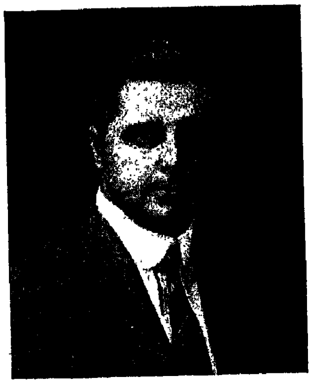
W. H. Lesser has been appointed combustion and mechanical engineer of the newly organized Penn Anthracite Collieries Company, Scranton, Pa. Mr. Lesser has wide practical experience in the preparation, utilization, and distribution of anthracite. As a member of the American Institute of Electrical Engineers he has served as chairman of the Committee on Applications to Mining Work.

D. W. Proebstel, for many years test engineer for the Portland General Electric Company, Portland, Ore., and its predecessors, has been promoted to the engineering department of the parent company, Central Public Service Corporation, Chicago. In his new position Mr. Proebstel will be assistant in electrical engineering to L. N. Boysen, who is assistant to the operating vice-president.

◆

J. B. MacNeill Now Distribution Manager

J. B. MacNeill, who has held successively the positions of circuit-breaker engineer, section leader on circuit breakers, and manager of the circuit-breaker engineering department of Westinghouse Electric and Manufacturing Company, has now received a new appointment as general manager of distribution engineering with headquarters at East Pittsburgh. This group comprises the engineering activities of switchboards, circuit breakers, meters, relays, high-voltage insulators, and lightning arresters. Improvements in modern switching equipment including the development of deion circuit breakers has been carried out under Mr. MacNeill's direction. He is a member of the National Electrical Manufacturers Association, and spent the summer of 1930 reviewing European practise on switchgear and distribution apparatus, after attending the World Power Conference at Berlin as a representative of NEMA.



J. B. MacNeill

◆

Albert M. Jacobs has been elected president of the South African Institute of Electrical Engineers for the current year. For the past five years he has been a member of the board and chief technical offices of the Electricity Supply Commission in the Union of South Africa.

Charles F. Ruffner has resigned as a vice-president of the Niagara-Hudson Power Company, but continues as chairman of the board and a director of the New York Power & Light Corporation.

◆

Thomas S. Wood, electrical manufacturers' agent, Seattle, recently attended the annual convention of the Sangamo Electric Company at Springfield, Ill.

◆

S. R. Inch, a vice-president of the Electric Bond & Share Company, has been elected executive vice-president.

◆

T. S. Perkins Named Merchandising Manager

T. S. Perkins has been chosen to head the new "merchandising department" of Westinghouse Electric and Manufacturing Company, East Pittsburgh, and will become executive of these new engineering activities with the title of general manager of merchandising engineering. In this position he will represent S. M. Kintner, assistant vice-president, in work of supply, appliance, refrigeration, and illuminating engineering departments. Mr. Perkins joined the Westinghouse organization immediately after his graduation from Worcester Polytechnic Institute in 1893 and has been with that company continuously since that time. For six years he has been a member of the Irwin (Pa.) Borough Council and president of that body for two years. He also has served as vice-president of the Westmoreland County Council, Boy Scouts of America; he was one of the organizers of the Irwin Saving and Trust Company, of which he is one of the directors, and is a past-president of the Irwin Chamber of Commerce.

T. S. Perkins

Obituary

A. H. Crossman, sales engineer for the Pacific Electric Mfg. Corp., San Francisco, California, and an Associate of the Institute since 1928, died at his home, Burlingame, Calif., February 8, 1931. A native of Cambridge, Mass., Mr. Crossman obtained his A. B. from Bowdoin College, Brunswick, Maine, in 1916 and his B. S. degree from M. I. T. in 1923, specializing in Economics at the first mentioned college and in hydroelectric engineering at M. I. T. In three years, from 1917 to 1920, he rose from second lieutenant to captain's rank in the Coast Artillery Corps, U. S. Army; three years later he joined the Southern Sierra Power Company at Riverside, Calif., embracing a student course which it was offering and advancing from Engineer in the distribution department to sales engineer, his last office.

◆

H. M. Walmsley, a Member of the Institute since 1921, died January 5 at Christ Hospital, Cincinnati, Ohio, following an operation for appendicitis. He had been in the electrical engineering field ever since 1905, when he took the G. E. Test Course at Schenectady immediately following graduation from Purdue University. He was born in Chicago, and his first work after completion of the Test Course was with the operating and construction departments of the Commonwealth Edison Company. From Chicago he went to Canton, Ohio, as resident engineer for Sargent and Lundy and the American Gas and Electric Company and also the Canton Electric Company. In the interests of the first two companies, he went to West Virginia to care for the erection of a new 10,000-kw. station for the Wheeling Electric Company. This was in 1913, and the following year he represented these same firms in the work of a new power station for the Ohio Light and Power Company, at Newark, Ohio. A $7,000,000 station and distribution system for the Cincinnati Gas and Electric Company was another product of his executive ability, as were the stations of the Kansas City Light and Power Company, the Public Service Company of Oklahoma, and the power and ice-plant of the Albilene Light, Water and Gas Company, Albilene, Texas. Mr. Walmsley was a member also of the American Society of Mechanical Engineers.

◆

Harry J. Hunsicker, electrical engineer of the New York Power and Light Corporation, Albany, died suddenly March 6th of acute dilation of the heart. He was born at Lehighton, Pa. July 5, 1879, and since 1907 had been an Associate of the Institute. His B. S. in E. E. was conferred upon him when he graduated from the Pennsylvania State College in 1901, and in July of that same year he entered the testing department of the General Electric Company at Schenectady. In August 1903 he joined the Hudson River Electric Power Company, first on electrical construction work, but rising shortly to the office of assistant electrical engineer. Mr. Hunsicker was active in building the Spier Falls hydraulic project, one of the important developments of the section in which he has spent most of his professional life.

◆

V. O. Chewning, assistant electrical engineer of the Illinois Terminal Railroad System, died February 15, 1931, in the Barnes Hospital, St. Louis, Mo. Mr. Chewning was born at Taylorville, Ill., in 1892; he served two years overseas during the World War and for three years was employed as local manager for the Central Illinois Public Service Company at Charleston, Illinois. Ten years ago he joined the Illinois Terminal Railway System, where his services were principally on the construction, maintenance and operation of railway substations. For a year and a half he was chief power dispatcher for the company at Taylorville, Illinois. He joined the Institute as an Associate in 1922.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Davis, R. H., Westinghouse E. & M. Co., East Pittsburgh, Pa.

Dawson, Leonard L., 98 Looker Ave., Springfield, N. J.

DiLucci, A., Box 1051, Chicago, Ill.

Duane, George B., Otis Elevator Co., Yonkers, N. Y.

Gale, R. E., 706 N. 19th St., Boise, Idaho.

Kigar, D. F., 1403 Minnie St., Port Huron, Mich.

Muncy, V. E., Ohio Mechanics Institute, Cincinnati, Ohio.

Nichols, F. A., 301 Belmont Apts., Seattle, Wash.

Prehn, Victor N., 940 Broad St., Newark, N. J.

Sherwood, W. E., Kew Gardens, 2700 Que St. N. W., Washington, D. C.

Sliney, David, 11 Orchard St., Cranford, N. J.

Van Wyck, P. V. R., Summit, N. J.

Local Meetings

Joint Meeting Held in Virginia

A joint meeting of the local Sections of the A. S. C. E., A. S. M. E., and A. I. E. E. and the Engineers Club of Hampton Roads was held at the Southland Hotel, Norfolk, January 30-31, 1931, with an attendance of 94. The program was as follows:

Friday Morning

F. F. Harrington, chairman, Virginia State Section, A. S. C. E., presiding.

Industrial Heating, by M. K. Clark, York Heating and Ventilating Corp.

The Fair of the Iron Horse—A moving picture. Business sessions of State Sections.

Luncheon

Charles W. Johnston, president, Engineers Club of Hampton Roads, presiding.

Welcoming Address, by Hon. E. Jeff Robertson, Mayor of Norfolk.

The North Atlantic Ice Patrol, by Captain William J. Wheeler, U. S. Coast Guard, with moving picture film.

Weather Predicting, by C. H. Richardson, meteorologist, U. S. Weather Bureau, Norfolk, Va.

Friday Afternoon

Motor bus excursion to Little Creek Terminal, Penn. R. R.; Cape Henry, Va.; Fort Story, (harbor defenses of Chesapeake Bay); and Virginia Beach.

Friday Evening

Dinner at Pine Tree Inn, Virginia Beach, J. H. Berry, chairman, Southern Virginia Section, A. I. E. E. presiding.

Technological Unemployment, by Professor Dexter S. Kimball, dean of the College of Engineering, Cornell University.

Electricity—Past, Present, and Future, by C. M. Ripley, General Electric Co.

Saturday

Golf; special visits to Navy Yard, Naval Base, and other places of interest.

At the business meeting of the A. I. E. E. Section the following officers were elected to take office February 1, 1931: J. H. Berry, Chairman; E. L. Lockwood, Secretary-Treasurer; E. S. Fitz and S. C. Foster, Executive Committee.

◆

Branches Organized at U. of Illinois and Rice Institute

The formation of Student Branches of the Institute at the University of Illinois and at Rice Institute was authorized by the Board of Directors at its meeting held on January 28, 1931. Both groups have completed their organization, and the following officers are in charge:

University of Illinois: W. P. Burgland, president; F. M. Deerhake, vice-president; G. L. Bodwell, secretary; R. R. Wood, treasurer.

Rice Institute: A. R. Edwards, president; D. B. Good, vice-president; M. E. Kattmann, secretary; K. Beyette, treasurer; A. M. Wittmann, executive committee member.

Future Section Meetings

Cleveland

April 16, 1931—Human Relations in Industry, by Whiting Williams. Joint meeting with Student Branch of Case School of Applied Science, at which two papers will be presented by students.

May 21, 1931—Annual dinner meeting. Speaker—W. S. Lee, vice-president and consulting engineer, Duke Power Company, and president, American Institute of Electrical Engineers.

Detroit-Ann Arbor

April 21, 1931—1000-Deg. Turbine, by Paul W. Thompson, Detroit Edison Co. Meeting to be held at the Detroit Edison Auditorium.

May 19, 1931—Subject and speaker to be announced later.

Lehigh Valley

April 24, 1931—Ladies' Night, to be held at Americus Hotel, Allentown, Pa.

May 16, 1931—Annual Meeting. System Development, by E. C. Stone, assistant to senior vice-president, The Philadelphia Company. Meeting to be held at Altamont Hotel, Hazleton, Pa.

Niagara Frontier

April 17, 1931—Art of Engineering, by Mr. Dohner, Westinghouse Electric & Mfg. Co.

May 15, 1931—Subject and speaker to be announced later.

Seattle

April 21, 1931—Annual joint meeting with the A. I. E. E. Student Branch of the University of Washington. Program under the auspices of the students.

May 19, 1931—The best paper submitted in the annual competition for prizes will be presented at this meeting.

Sharon

May 5, 1931—The Contributions of Telephone Research to the Talking Motion Picture Industry, by J. O. Perrine, Associate Editor, *Bell System Technical Journal.*

Spokane

April 24, 1931—Joint meeting with the Student Branches of The State College of Washington and University of Idaho. Papers by local members and students. Meeting to be held at Pullman, Wash.

May 22, 1931—Annual Dinner Meeting. History of the Electrical Development of the Inland Empire, by John B. Fisken. Election of officers.

Toledo

April 17, 1931—High Lights in the Glass Industry, by A. H. Stebbins, Libbey Ford Glass Co. Storage Batteries, by W. E. Dunn, Electric Storage Battery Co.

May 22, 1931—Speakers—T. J. Nolan, Toledo Edison Co. and J. T. Greene, Police and Fire Alarm System.

Past Section Meetings

Akron

Electronic Tubes and Their Applications, by H. P. Sparkes, Westinghouse Electric & Mfg. Co. Demonstrations. February 12. Attendance 150.

Atlanta

Speed, Unemployment and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engineering Corp. Dinner preceded the meeting. February 27. Attendance 73.

Baltimore

Marvels of Sound Transmission, by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. Demonstrations. Meeting held jointly with all engineering societies of Baltimore and the Association of Commerce. Dinner in honor of the speaker preceded the meeting. January 16. Attendance 1,700.

Municipal Rapid Transit Subways of New York City, by Robert Ridgway, chief engineer, Board of Transportation of New York City. Illustrated. Joint meeting of the local engineering societies, sponsored by the A. S. C. E. February 4. Attendance 120.

The proposed bill for the Registration of Engineers in the State of Maryland was discussed by the following speakers: Henry G. Perring, S. S. Steinberg, W. B. D. Penniman, W. B. Kouwenhoven F. T. Leilich, E. D. Edmonston, A. L. Penniman, and others. After considerable discussion a resolution was unanimously adopted stating that the enactment of the registration law in the Maryland Free State was neither desirable nor beneficial to either the public or the members of the engineering profession. February 17. Attendance 200.

Lightning Research, by Edward W. Beck, Westinghouse Electric & Mfg. Co. Mr. Beck presented a résumé of the lightning researches carried out in Tennessee and New Jersey, and showed numerous slides illustrating experiments with the auto-valve arrester that have been performed on transmission lines. February 20. Attendance 78.

Cincinnati

Television: Its Physical, Psychological, and Fundamental Principles, by Dr. J. O. Perrine, associate editor, *Bell System Technical Journal.* Demonstration of the use of the scanning disk and photoelectric cell. January 15. Attendance 570.

Some New and Interesting Developments in Engineering and Research, by A. M. Dudley, Westinghouse Electric & Mfg. Co. February 12. Attendance 98.

Cleveland

The Flying Telephone, by F. M. Ryan, Bell Telephone Laboratories, Inc. The development work which was necessary before actually designing telephone equipment for aeronautical purposes was explained and illustrated. February 19. Attendance 176.

Columbus

Recent Advances in Aircraft Communication, by F. M. Ryan, Bell Telephone Laboratories, Inc. Illustrated by lantern slides and a Western Electric sound picture "The Flying Telephone;" also, an exhibition of the types of apparatus employed in aviation radio installations. February 20. Attendance 135.

Connecticut

Glass Insulation, by Wm. W. Shaver, Corning Glass Works. Slides and moving pictures were presented illustrating the manufacture of glass, methods of handling and moulding glass, and the comparative tests of glass insulators with porcelain insulators. February 11. Attendance 63.

Dallas

St. Louis-Dallas Underground Toll Cable, by C. W. Nystrom, Southwestern Bell Telephone Co. Illustrated with films and slides. January 19. Attendance 106.

Lighting the Home, by Miss Ethel Hudson, Dallas Power & Light Co. Illustrated with slides. Joint meeting with Illuminating Engineering Society. February 16. Attendance 94.

Denver

Radiation, by Paul Luckenbach, General Electric Company. Joint meeting with the A. S. M. E., A. C. S., Colorado Scientific Society, and Teknik Club. February 6. Attendance 160.

Detroit-Ann Arbor

Electric Power Cables, by G. B. McCabe, Detroit Edison Co., and L. F. Hickernell, Allied Engineers, Inc. This subject was divided into two parts; Mr. McCabe outlined the manufacture, construction, installation, operation, and recent improvements in design, and Mr. Hickernell spoke on the application and specifications. Slides were used to illustrate the design and use of many kinds of cable. January 20. Attendance 200.

The Detroit Toll Board, by E. C. Balch, Michigan Bell Telephone Co. Preceding this meeting, there was an inspection trip through the Detroit Toll Board. February 17. Attendance 200.

Indianapolis-Lafayette

The Deion Breaker, by B. P. Baker, Westinghouse Electric & Mfg. Co. Mr. Baker discussed the theory underlying the construction and uses of the Deion air breaker and Deion grid breaker. Illustrated. February 20. Attendance 62.

Iowa

Electric Eye, Stroboscope, and Televox, by H. B. Stevens, Westinghouse Elec. & Mfg. Co. Apparatus was used to demonstrate the use of the Electric Eye and Televox. Joint meeting with the Iowa State College Branch. February 6. Attendance 339.

Ithaca

Outdoor Lighting, by E. H. Powell, General Electric Co. February 20. Attendance 35.

Lehigh Valley

Recent Developments in Generation and Transmission of Electric Power, by R. C. Bergvall, Westinghouse Electric & Mfg. Co. Outline of recent developments in electrical equipment to promote system stability under faulty or abnormal conditions. Meeting held at Hotel Casey, Scranton, Pa. February 4. Attendance 93.

The Future of Vacuum Tubes, by Dr. Albert W. Hull, General Electric Co. Joint meeting with the Engineers Club, held at Hotel Easton, Easton, Pa. February 27. Attendance 175.

Los Angeles

Dynamic Power Limits of Transmission Systems, by Wm. S. Peterson, Los Angeles Bureau of Power & Light. Mr. Peterson used the Griscom Mechanical Devices for illustrating stability problems, and also used a number of slides showing methods of calculation. Discussion followed. February 17. Attendance 76.

Louisville

Speed, Unemployment, and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engg. Corp. February 20. Attendance 52.

Madison

Joint meeting with the University of Wisconsin Branch, at which the following papers were presented by students:

Automatic Oscillographs, by J. D. Cobine;

Trends in Electrical Construction, by R. J. Nickles, Jr.;

Copper-Oxide Rectifiers, by John L. Jones. February 18. Attendance 55.

Memphis

The Operation of the Distribution System of the Memphis Power & Light Co., by H. E. H. Martin, chief dispatcher, and W. A. Gentry, supt. of Distribution Operation Dept. of the above company. Two films entitled "Voltage Regulators," and "Oil Circuit Breakers." February 10. Attendance 34.

Speed, Unemployment, and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engg. Corp., March 9. Attendance 84.

Minnesota

Electrification of the Cascade Tunnel, by J. E. Hawe, Great Northern Railway Co. Illustrated with moving pictures. March 4. Attendance 100.

Niagara Frontier

Interruption of High Currents at Low Voltages, and Application of Research to Development of Low-Voltage Air Circuit Breakers, by Knute Falck, I. T. E. Circuit Breaker Co. Illustrated. Film—"Building New York's Newest Subway." Dinner in honor of the speaker at the Hotel Niagara. February 20. Attendance 70.

Oklahoma City

Inductive Coordination of Communication and Electric Supply Equipment, by E. B. Jennings, Southwestern Bell Telephone Co., and C. E. Bathe, Oklahoma Gas & Electric Co. Dinner preceded the meeting. January 26. Attendance 54.

Recent Technical Developments in the Electrical Industry, by I. T. Monseth, Westinghouse Elec. & Mfg. Co. Illustrated with a number of pictures of developments made by the above company during the past year. February 23. Attendance 60.

Philadelphia

Some Developments and Applications in Electrical Communications, by R. D. Parker, American Tel. & Tel. Co. March 9. Attendance 225.

Pittsburgh

Research By-Products, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Mr. Thomas described and demonstrated a number of unusual applications of photo- and grid-glow tubes and other electronic devices. Joint meeting with I. R. E. and Engineers Society of Western Pennsylvania. February 9. Attendance 236.

Pittsfield

Color Photography, by Glenn E. Mathews, Eastman Kodak Co. Illustrated with slides and movies. February 17. Attendance 400.

River of Mystery—The Orinoco, by Dr. Herbert S. Dickey, Explorer and Scientist, Museum of the American Indian. Dinner preceded the meeting. March 3. Attendance 900.

Portland

Joint dinner meeting with the Oregon State College Branch, at which the following papers were presented by students:

The Characteristics of Pentode Tubes, by N. G. Reetz;

A High Voltage Corona Rectifier, by D. C. Foster and Wm. R. Bullis;

A Per Cent Registration Calculator for Watthour Meters, by C. E. Boucher. February 30. Attendance 85.

Artificially Generated Sun Light, by Paul Luckenbach, General Electric Co. Illustrated with lantern slides. March 3. Attendance 140.

Rochester

Materials Handling, by C. B. Crockett, Industrial Truck Association. Mr. Crockett stressed the importance of scientific handling of materials in large industrial plants and its cost and effect on production. Joint meeting with the I. R. E., A. S. M. E., R. E. S. October 9. Attendance 89.

The Advantages of Increased Power for Clear Channel Broadcasting Stations, by O. H. Caldwell, editor of *Electronics*;

Extending the Radio Frequency Spectrum, by A. H. Taylor, director, Naval Research Laboratories. Joint meeting with the I. R. E. November 21. Attendance 231.

Recent Achievements in Electrical and Steam Generation, by E. M.

Gilbert, W. S. Barstow & Co. Joint meeting with the I. R. E., A. S. M. E., and R. E. S. January 8. Attendance 208.

The Story of Commercial Enameling, by James H. Snyder, Pfaudler Co. Mr. Snyder described the difference between glass and paint enameled goods and demonstrated the Pfaudler method of mixing glass enamel. Joint meeting with the I. R. E., A. S. M. E., and R. E. S. January 22. Attendance 83.

Communism in the Abstract, by Colonel Hugh L. Cooper. Slides were used to illustrate the various engineering projects which Colonel Cooper has undertaken in Russia, and particularly the construction of the dam on the Dnieper River. Joint meeting with the I. R. E., A. S. M. E., and R. E. S. February 5. Attendance 416.

Making of Radio Tubes, by Paul T. Weeks, Raytheon Production Corp. Mr. Weeks analyzed the manufacturing end of the radio tube industry explaining, by the use of slides, the entire process from the manufacture of the elements to the finished tube assembly. Joint meeting with the I. R. E., A. S. M. E., and R. E. S. February 12. Attendance 77.

Transoceanic Telephony, by Henry Nicholson, Lyddon, Hanford & Kimball Co. Luncheon with the I. R. E., A. S. M. E., and R. E. S. sponsored by the A. I. E. E. January 6. Attendance 43.

What Can Retraining Do for Unemployment, by John A. Randall, president, Mechanics Institute. Luncheon with the I. R. E., A. S. M. E., and R. E. S., sponsored by the A. I. E. E. January 13. Attendance 50.

One Year's Progress in City Manager Government, by Stephen B. Story, city manager. Luncheon with the I. R. E., A. S. M. E., R. E. S., sponsored by the A. I. E. E. January 20. Attendance 66.

Telephone Traffic in Rochester, by John P. Boylan, Rochester Telephone Corp. Luncheon with the A. S. M. E., I. R. E., and R. E. S. January 27. Attendance 66.

St. Louis

Modern Developments in Large Waterwheel Generators and Synchronous Condensers, by Marvin W. Smith, Westinghouse Electric & Mfg. Co. Illustrated with slides. February 18. Attendance 85.

San Antonio

A. E. Allen, General Electric Co., discussed some of the recent developments of the electrical industry. Films were shown entitled "The Trend in Turbine Design," and "The Trackless Trolley Bus." February 16. Attendance 62.

Speed, Unemployment, and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engg. Corp. March 4. Attendance 92.

Schenectady

Vacuum Tubes in Electrical Engineering, by W. C. White, General Electric Co. Illustrated with demonstrations. January 16. Attendance 200.

The World Background of American Business, by Charles A. Eaton, Member of Congress from New Jersey, and Member of the House Foreign Affairs Committee. February 6. Attendance 75.

The Manufacture of Iron and Steel, by G. A. Richardson, Bethlehem Steel Co. Moving pictures showing in detail the manufacturing methods in use in the steel industry were presented. February 20. Attendance 260.

Sharon

Recent Interesting Aeronautical Developments, by Samuel P. Mills, N. Y. University. Illustrated with slides and film entitled "Mexico." March 3. Attendance 227.

Spokane

A Résumé of Recent Developments in Predetermination of System Performance, by Dean H. V. Carpenter, State College of Washington. Discussion followed. February 27. Attendance 20.

Toledo

The Flying Telephone, by F. M. Ryan, Bell Telephone Laboratories, Inc. Illustrated with lantern slides, motion pictures, and demonstrations. February 17. Attendance 350.

A New Combustion Indicator, by Max Neuber, Motormeter Gauge & Equipment Co.;

Vacuum Treatment of Insulating Oils, by R. P. Dunmire, Buckeye Laboratories, Inc. March 6. Attendance 60.

Toronto

Applied Psychology, by Prof. S. N. F. Chant, University of Toronto. Considerable discussion followed this talk. Joint meeting with the Engineering Institute of Canada. February 12. Attendance 180.

Operation and Maintenance of Generating Stations, by A. S. Robertson, Hydro-Electric Power Commission. Illustrated with slides. February 27. Attendance 132.

Urbana

Lighting Architecture, by H. S. Logan, Holophane Co. Illustrated with slides and film entitled "Making Mazda Lamps." February 18. Attendance 120.

Utah

Television, by S. W. Pixton, Mountain States Tel. & Tel. Co. Mr. Pixton gave an illustrated lecture upon the history and developments of television, particularly from the standpoint of the Telephone Co. Informal dinner preceded the meeting. February 16. Attendance 80.

Vancouver

Joint meeting with the University of British Columbia Branch, at which the following papers were presented by students;

Manually-Operated Telephone Exchanges, by J. W. Smith;

Incandescent Lamps, by D. Smith;

Mercury Arc Rectifiers, by M. A. Thomas. March 2. Attendance 50.

Washington

Television, Its Fundamental, Physical and Psychological Principles, by Dr. J. O. Perrine, associate editor, *Bell System Technical Journal*, Dr. Perrine demonstrated the photoelectric cell and neon lamp. March 10. Attendance 260.

Worcester

Power Factor and Its Relation to Induction Motor Applications, by Prof. H. A. Maxfield, Worcester Polytechnic Institute. February 25. Attendance 30.

Past Branch Meetings

University of Akron

Underground Power Distribution Systems, by G. E. Buffington, student. Frank Marcinkoski, student, gave a demonstration of shock resuscitation. February 26. Attendance 10.

Alabama Polytechnic Institute

Detecting Rail Fissures, by J. M. Johnson, student. Mr. Jager, student, gave a description of his summer work as a mechanic in the mines. February 12. Attendance 15.

University of Alabama

Methods of Breaking Arcs, by Prof. F. R. Maxwell, Jr., counselor;

Electric Welding, by C. Hendrickson, student;

Pile Bridges, by W. G. Gable, student. December 15. Attendance 8.

Layout of Anniston Primary Substation, by Paul Clark, student;

Attention Paid to Safety by Large Companies, by W. H. Croft, student. January 12. Attendance 7.

Power Rates, by W. G. Gable, student;

Synchronous Condensers, by Paul Clark, student;

Electric Railways, by C. Hendrickson, student. January 26. Attendance 10.

Electrical Engineering in Aviation, by Prof. Leslie Walker. February 9. Attendance 8.

Business meeting. February 23. Attendance 8.

Professional Relationships, by Dr. Benjamin A. Wooten, head, Physics Dept.;

Opportunities in the A. I. E. E., by Prof. Fred R. Maxwell, Jr., counselor. February 27. Attendance 43.

University of Arkansas

Discussion of plans for Engineers' Day. February 18. Attendance 22.

Armour Institute of Technology

Asbestos Insulated Wire and Cable, by William Tierney, Rockbestos Products Corp. February 20. Attendance 52.

Talking Motion Pictures, by H. Merrill Smith, Electrical Research Products, Inc. March 6. Attendance 60.

University of British Columbia

Joint meeting with the Vancouver Section at which three papers were presented by students. (See report under "Past Section Meetings.")

Polytechnic Institute of Brooklyn

A-C. Distribution, by James G. Grover, student;

The Trend in A-C. Transmission, by Frank Powers, student;

Cathode Ray Oscillograph, by R. G. O'Sullivan, student. Frank Powers was awarded first prize and Robert G. O'Sullivan second prize. February 17. Attendance 18.

The Advantages Gained by the Young Engineer who Joins a Technical Society, by Roy V. Wright, president A. S. M. E. Joint meeting of the four technical societies. February 19.

Michael Faraday, by Leon Danner, student;

X-Ray Crystallography, by Sam Siegel, student;

A New Method of Scanning for Television, by Ivan Block, student. Ivan Block won first prize and Sam Siegel second prize. March 2. Attendance 25.

California Institute of Technology

L. H. Means, General Electric Co., outlined the problems met by industry in dealing with its operating personnel. He also gave a brief description of the General Electric Co. and its policies and practises toward employees. February 17. Attendance 52.

University of California

Initiation banquet at which the following papers were presented:

Why I Joined the A. I. E. E., by J. J. Cassidy, Jr., student;

Latest Developments in Electrical Engineering, by P. B. Garrett, Westinghouse Electric & Mfg. Co., and chairman San Francisco Section, A. I. E. E. February 3. Attendance 50.

New Developments in Toll Transmission, by C. V. Fowler, Pacific Tel. & Tel. Co. February 25. Attendance 38.

Case School of Applied Science

Electrical Knowledge of Faraday's Time, by Dr. W. E. Wickenden, president, Case School of Applied Science;

Faraday's Contributions to Science, by A. Friedman, student;

Faraday, the Man and His Life, by K. Spangenberg, student. Dinner meeting. March 3. Attendance 60.

Clemson Agricultural College

Life of Steinmetz, by C. V. Rentz, student;

75-Kv. Submarine Cable, by C. J. Davenport, student;

Miniature Switchboards, by L. W. Foster, student;

Radio Telephone Service to Ships at Sea, by C. DuRant, student;

Current events discussed by H. S. Montgomery. January 8. Attendance 24.

Life of Watt, by J. P. Littlejohn, student;

Football Field Illumination, by A. B. Coggins, student;

Current events discussed by G. H. Epting, student. January 22. Attendance 20.

Colorado State Agricultural College

Business meeting. February 9. Attendance 12.

The Application of Electricity in the Rayon Industry, by Prof. D. Bachelder. January 28. Attendance 13.

University of Colorado

Federal Regulation of Radio, by G. W. Earnhart, asst. radio inspector, Radio Commission. February 18. Attendance 58.

Carrier-Current Pilot of the Vincent 220-Kv. Transmission Line of the Southern California Edison Co. Ltd., by F. B. Doolittle, Southern California Edison Co., Ltd. February 23. Attendance 70.

An Explanation and Demonstration of Photophone Equipment, by A. S. Anderson, General Electric Co. Films—"The Electric Ship," "A Trip Through the Cascade Tunnel," and "Radio Active Rays." March 4. Attendance 325.

Cooper Union

Symposium on Electro-optics, by A. Ginsberg, D. Briansky, and G. Kosolopoff, students. Illustrated by experiments. March 4. Attendance 32.

Cornell University

Electricity in Railway Transportation, by R. R. Brainard, Branch secretary;

Trolley Buses, by O. K. Williams, student;

A Canadian Canoe Trip, by R. E. Nelson, student. February 18. Attendance 16.

University of Denver

Railway Electrification, by Frank Nutt, student. January 13. Attendance 24.

Film—"Building New York's Newest Subway." January 27. Attendance 33.

Photometers, by Louis Duval, student;

Hunting of Synchronous Machines, by F. W. Olmsted, Branch secretary. February 3. Attendance 21.

Film—"On the Pathways of Progress." February 10. Attendance 25.

High- and Low-Frequency Oscillators, by G. H. Lovins, student. February 17. Attendance 15.

University of Detroit

Inspection trip to the Del Ray power house and the Waterman substation of the Detroit Edison Co. January 15. Attendance 40.

Television, by H. Folkrod, Michigan Bell Telephone Co. Film—"History of Wireless." February 12. Attendance 75.

Drexel Institute

My Work in the Lightning Laboratory of the Pennsylvania Power & Light Co., by H. C. Werner, student. February 10. Attendance 18.

Philadelphia Electric's Present Transmission System, by W. W. Woodruf, Philadelphia Electric Co. March 3. Attendance 34.

University of Florida

The History and Development of Short-Wave Transmission in Radio, by R. E. Herrick, student;

The Construction of Audio Transformers, by R. M. Weinkle, student. March 9. Attendance 38.

Georgia School of Technology

Film—"The Single Ridge." February 11. Attendance 95.

Harvard University

Corrective Research, by F. V. Weeks, student;

A Summer with Westinghouse, by C. W. Waldow, student;

Between Students, by J. L. Beaver, student. March 4. Attendance 17.

University of Idaho

Film—"Construction of Wire." January 28. Attendance 63.

Two talks by students. February 3. Attendance 35.

Film—"Wizardry of Wireless." February 4. Attendance 55.

Time Pieces, by Glenn Gage, student. Talk by Professor J. H. Johnson, counselor. February 17. Attendance 37.

Motor Characteristics, by H. L. Vincent, General Electric Co. March 3. Attendance 37.

Kansas State College

H. M. Lowe, who recently returned from three years' work in South America related his experiences while there. Election of officers. February 5. Attendance 105.

University of Kansas

Howard Sutton, student, gave a technical report on a Westinghouse Relay for the control of transformers in parallel, after which he presented the relay to the electrical department for research work.

Rectification of Alternating Current Waves, by B. Brown, student. February 26. Attendance 45.

University of Kentucky

Inspection trip through the local telephone exchange. March 5. Attendance 41.

Lafayette College

Business meeting. March 7. Attendance 17.

University of Louisville

The Life of Edison, by E. B. Wagner, student;

Deion Circuit Breakers, by C. R. Bost, student. Illustrated. February 13. Attendance 21.

Marquette University

Debate between Mr. Horowitz and H. Jossell, students, on Coeducation at Marquette. Mr. Harriss of South Africa related living conditions in his home land. Joint meeting with the A. S. C. E. and A. S. M. E. Branches. December 18. Attendance 49.

Welding Generators—Their Construction and Applications, by K. L. Hansen, Northwestern Manufacturing Co. Joint meeting with the School of Engineering of Milwaukee Branch. January 7. Attendance 21.

Massachusetts Institute of Technology

Illumination and Color, by K. J. Germeshausen, student;

Broadcasting Development, by A. E. Cullum, student. Dinner preceded the meeting. February 19. Attendance 50.

Inspection trips to the General Electric Company in East Boston and West Lynn. March 4. Attendance 32.

Michigan College of Mining and Technology

Discussion of plans and appointments of committees for electrical show. February 17. Attendance 74.

Michigan State College

Film—"The Single Ridge." February 24. Attendance 25.

School of Engineering of Milwaukee

The Radio Control of Garage Doors, by Mr. Nethercut, Barber-Colman Co. Demonstrated.

The Theory of the Photoelectric Cell, by Mr. Greisel, student. Karl Werwath, student, reviewed some of the latest developments in the electrical field. February 11. Attendance 75.

Missouri School of Mines and Metallurgy

Two films entitled "The Benefactor," and "Thomas A. Edison." December 18. Attendance 23.

Life of Faraday, by G. L. Leisher, student;

Description of the Life of Steinmetz, by Prof. I. H. Lovett, Counselor. M. R. James, student, gave a talk on his experiences while employed by the Union Electric Co. January 28. Attendance 16.

Business Meeting. February 11. Attendance 13.

Films—"Atomic-Hydrogen Welding" and "Aircraft Accessories." February 25. Attendance 167.

The Desire to Do a Thing, by Branch Rickey, vice-president of the St. Louis Cardinals. February 27. Attendance 423.

University of Missouri

Annual Dinner. Short talk by J. S. Palmer, Kansas City Power & Light Co. February 24. Attendance 43.

Marine Propulsion, by F. V. Smith, General Electric Co. Joint meeting with the A. S. C. E., and A. S. M. E. Branches. March 9. Attendance 50.

Montana State College

Film—"From Mine to Consumer." February 12. Attendance 152.

Why An Engineer Should Take Public Speaking, by Walter J. Williams, student;

White Lights North of Arctic Circle, taken from *Power Plant Engineering*, presented by Herbert Archibald, student;

Some Aspects of Federal Regulation of Water-Power Development, taken from Electrical Engineering, presented by James Pepper, student;

Detecting Hidden Fissures in Rails, taken from Electrical Engineering, presented by Ward Rightmire, student. February 19. Attendance 143.

Artificial Sunlighting Now Challenges the Sun, taken from *Electrical World*, presented by E. N. Blannin, student;

The Development of Lighting During the Year 1930, taken from *General Electric Review*, presented by Edward Fisher, student;

Gasoline Pump Motors, taken from *Electric Journal*, presented by Leonard Estey, student. February 26. Attendance 129.

Electricity and Light During 1930, taken from *Electrical World*, presented by Armin J. Hill, student;

Floating Electric Power Plant, by Homer T. Lambdin, student;

Constant-Voltage Regulators, by Paul McAdam, student. March 5. Attendance 134.

University of Nebraska

Oil Circuit Breaker Phenomena, by G. W. Swallow, American Brown Boveri Co. Inc. Film—"Electric Locomotives and Trains in Switzerland." February 3. Attendance 55.

Inspection trip through the U. S. Government Radio Monitor Station, conducted by Benjamin Wolf, manager of the Station; also through the Grand Island Sugar Beet Factory, conducted by U. Anderson, chemist. February 8. Attendance 28.

Picture Transmission by Wire, by Cecil Donley, Lincoln Telephone & Telegraph Co. February 18. Attendance 40.

Opportunity for Engineers Today, by Roy V. Wright, president, A. S. M. E. March 3. Attendance 120.

University of Nevada

Electricity and Its Application to the Mining Industry, by J. A. Fulton, director, Mackay School of Mines. February 4. Attendance 16.

Electric Water Purifiers, by Chester Elliott, student;

New Developments in Vacuum Tubes, by Jack Hough, student. February 11. Attendance 15.

Electron Tubes, by H. C. Stanley, General Electric Co. Illustrated with motion pictures. February 18. Attendance 68.

Newark College of Engineering

Direct-Coupled Amplifiers, by W. B. Wible, student;

Mercury Vapor Turbines, by S. F. Spence, student;

Generator-Voltage Regulation, by G. McSweeney, student. February 24. Attendance 32.

University of New Hampshire

Films—"The Potter's Wheel," "Revelations by the X-Ray," and "The Cat and the Kit." January 10. Attendance 36.

The Photoelectric Cell and Some of Its Applications, by J. J. Carlen, student. January 17. Attendance 36.

Electrification of Railways, by F. M. Jones, student. January 24. Attendance 33.

Harnessing Ocean Temperatures, by K. S. Savage, student;

A New Radio Battery that Breathes Air, by O. K. Reid, student;

Explanation and Demonstration of Magnetic Arc Blow-Out, by G. R. Walden, student;

Why Fraternities Should not Exist on a College Campus, by C. A. Dolloff, student;

Why Fraternities Should Exist on a College Campus, by H. R. Wood, student. January 31. Attendance 30.

Aluminum Electrolytic Condenser and Lightning Arrester, by P. J. Stafford, student;

Radio Programs by Electrical Transcription, by R. M. Sawyer, student;

Flood Control in the Mississippi Valley, by J. J. Cunningham, student. February 7. Attendance 34.

Films—"Turbines," and "Dynamic America." February 21. Attendance 35.

Induction Generators, by R. Osgood, student;

Aurora, The Elusive Mystery of Science, by F. Dickey, student;

The Polarized Bell, by C. Matoian, student;

Operation of D-C. Generators in Parallel, by L. Barker, student;

Why A-C. Current Leads the Voltage 90 Degrees with a Condenser in the Circuit, by F. Perkins, student. February 28. Attendance 34.

University of New Mexico

The Life and Work of Oliver Heaviside, by S. Fish, student;

Control by Radio, by H. Mendenhall and E. Huffman, students. February 26. Attendance 11.

College of the City of New York

Discussion of Branch activities. February 19. Attendance 15.

Business meeting. March 5. Attendance 18.

University of North Carolina

Block Signals, by A. C. Robertson, student;

Electrical Experiences, by O. J. McCall, student. February 12. Attendance 30.

Union Management Cooperation Through Research, by Morris L. Cooke, consulting engineer. Joint meeting with the Taylor Society. February 25. Attendance 90.

North Dakota State College

Annual Engineers' Banquet. My 30 Years' Experience Since Graduating from College, by M. S. Hyland, consulting engineer, Fargo, N. D. Film—"The Age of Riveted Steel." February 19. Attendance 108.

Preservation of Wood, by Wayne Curtis, student;

Film—"Blasting the Water Highways of America." February 25. Attendance 54.

University of North Dakota

General Electric Motors and Motor Application, by C. W. Randall, General Electric Co. February 11. Attendance 21.

Transportation Electrification, by Eugene Becker, student. March 4. Attendance 16.

University of Notre Dame

Thunderstorms and Lightning Discharge, by Prof. Daniel Hull, Dept. of Physics;

Resonance, by Edward Coomes, student;

Cross-Talk Elimination, by D. D. Mohler, student;

Life of Faraday, by A. V. Alvino, student. Patrick Murray presented the usual news digest. February 16. Attendance 68.

Turning the Light of Everyday Experience on the Economics of Today's Business and Related Activities, by L. B. Andrus, Central Indiana Power Co.;

Practical Telephony, by Henry Culver, student;

The Mercury Arc Rectifier, by Hugh Ball, student. Patrick Murray presented the usual news digest. March 2. Attendance 80.

Ohio Northern University

Film—"Government Aviation Developments." February 19. Attendance 38.

Discussion of future meetings and nomination of new officers. February 26. Attendance 24.

Looking Ahead in Aviation, by D. Cottrell, student. Election of officers as follows: O. R. Jacobs, president; B. Wyant, vice-president; W. Gideon, secretary; O. Hawes, treasurer. March 5. Attendance 18.

Ohio State University

Vacuum Tubes in Industry, by S. D. Fendley, General Electric Co. February 26. Attendance 22.

Ohio University

Film—"Induction Voltage Regulator." February 16. Attendance 8.

Oklahoma A. & M. College

Discussion of plans for the electrical show. February 5. Attendance 19.

Dry Cells—Their Manufacture and Use, by Paul Ratliff, student. Illustrated. February 12. Attendance 30.

Oregon State College

Safety in the Industries, by A. E. Eicken, National Safety Council. Illustrated with slides. February 16. Attendance 13.

Joint meeting with the Portland Section at which three papers were presented by students. (See report under "Past Section Meetings").

Discussion of Branch activities. March 2. Attendance 21.

University of Pennsylvania

The Thyratron Multi-Bopper Circuit, by Newbern Smith, student. February 19. Attendance 22.

Pratt Institute

Electric Railways, by J. L. Thomson, student;

Production of Aluminum, by N. J. Cherry, student. February 19. Attendance 15.

Purdue University

The Deion Circuit Breaker, by B. P. Baker, Westinghouse Electric & Mfg. Co. Illustrated with slides. February 10. Attendance 90.

Rensselaer Polytechnic Institute

Artificial Transients of Transmission Lines with Particular Reference to Performance of Lightning Arresters, by K. B. McEachron, General Electric Co. Illustrated with slides. February 10. Attendance 70.

Rose Polytechnic Institute

Illumination of Aviation Fields, by Bruce Wells, student. Film—"Aviation Lighting." March 4. Attendance 29.

University of Santa Clara

The Historical Development of the Allis-Chalmers Mfg. Co. and Their Motor and Dynamo Products, by William F. Snyder, Allis-Chalmers Mfg. Co. January 29. Attendance 105.

University of South Carolina

The Kaplan Automatic Adjustable Blade Turbine, by R. Brooks, student;

A Laboratory Method of Measuring the Capacity of Small Condensers, by C. L. Fishburne, student. February 16. Attendance 26.

The Vacuum-Tube Voltmeter, by J. W. Palmer, student;

Will You Lose Your Job Because of a New Machine, by J. B. Dent, student;

Electronic Tubes—Their Present and Future, by J. Oberschain, student. February 23. Attendance 30.

Business meeting. March 2. Attendance 9.

The Development of Motion Pictures, by R. Phillips, student;

Baron Munchausen Out-Lied with Truth, by David Peele, student. March 9. Attendance 29.

University of Southern California

Business meeting. February 4. Attendance 30.

L. A. Buese, Los Angeles Gas & Elec. Corp., discussed the remote control of substations by means of a step-by-step relay system. February 11. Attendance 32.

Aircraft Communication, by Del Mar Wright, Western Air Express and Transcontinental Air Transport, Inc. February 18. Attendance 32.

The Electrical Measurement of Acoustical Properties, by D. P. Loye, Electrical Research Products, Inc. February 25. Attendance 27.

STREET LIGHTING, by O. W. Holden, Los Angeles Bureau of Power & Light. March 4. Attendance 30.

Stanford University

TRANSFORMER CONSTRUCTION, by W. C. Smith, General Electric Co. February 4. Attendance 21.

Stevens Institute of Technology

LIFE OF JOSEPH HENRY, by Donald Naughton, student. February 24. Attendance 21.

Syracuse University

SOME EARLY A. I. E. E. MEETINGS, by Prof. C. W. Henderson, counselor. February 13. Attendance 23.

MEASUREMENT OF LIGHTNING DISTURBANCES ON TRANSMISSION LINES, by John Henderson, student;

THE BRIDGE TRANSFORMER, by Richard Stone, student. February 20. Attendance 25.

HYDROGEN-COOLED GENERATORS, by Donald Brown and Ernest Wood, students;

COOLING FINS, by Edward Schweitzer and Stanley Scerbinski, students. February 27. Attendance 25.

DISTRIBUTION SYSTEM OF SYRACUSE LIGHTING CO., by L. L. Cross, Syracuse Lighting Co. March 6. Attendance 24.

University of Tennessee

Debate—COPPER VERSUS ALUMINUM CABLES FOR TRANSMISSION LINES, by J. M. Brooks and J. Barnwell, students. February 19. Attendance 21.

University of Texas

STEAM GENERATING EQUIPMENT, by O. K. Irvine, student;

ELECTRICAL GENERATING EQUIPMENT, by D. Sussin, Branch secretary;

SWITCHBOARD EQUIPMENT, by E. W. Toepperwein, student. February 12. Attendance 18.

University of Utah

TELEVISION, by Seth Pixton, illustrated. February 24. Attendance 25.

University of Vermont

THEORY OF THE STENODE RADIOSTAT, by A. L. Howard, student. February 24. Attendance 21.

Virginia Military Institute

Film—"Conowingo." February 18. Attendance 50.

500 M. P. H.—CAN'T BE DONE, by F. A. Tyler, student;

WHAT THE ELECTRICAL INDUSTRIES THEMSELVES EXPECT OF THE ELECTRICAL STUDENT, by R. E. Fort, student;

THE SUPER-MAGNETIC FIELD, by E. R. Trapnell, Student. February 19. Attendance 46.

Virginia Polytechnic Institute

Discussion of Branch activities and of the recent lecture given by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc., entitled MARVELS OF SOUND TRANSMISSION. February 12. Attendance 15.

TESTING OF DRY-CELL BATTERIES AS DONE AT THE BUREAU OF STANDARDS, by M. H. Mills, student. February 26. Attendance 18.

Washington State College

Election of officers as follows: L. N. Hatfield, president; A. Keto, vice-president, G. C. O'Brien, secretary; H. Stingle, treasurer. January 21. Attendance 29.

Washington University

Discussion of Branch activities. February 26. Attendance 15.

West Virginia University

The following talks were given by students;

ELECTRICITY IN THE CEMENT INDUSTRY, by C. J. DeLavey;

INDUSTRY VERSUS TECHNICAL EDUCATION, by R. W. Blair;

THE GROWTH OF 1930, by R. N. Kennedy;

AERONAUTICAL RADIO COMMUNICATION, by C. J. McCormack;

IMPROVEMENTS TO MAKE ELEVATORS FASTER AND SAFER, by J. N. Simpson;

AIR-CELL BATTERIES, by K. De Moss;

ELECTRIFICATION OF B. & O. RAILROAD, by R. C. Warder;

90 MILES PER HOUR IN A TROLLEY CAR, by J. M. Morgan. February 10. Attendance 25.

The following talks were given by students:

FLOPS BY FAMOUS INVENTORS, by H. V. Locker;

ELECTRICAL INDUSTRIES, by M. L. Sprigg;

GENERAL PRINCIPLES OF SOUND RECORDING, by V. S. Monteith;

LOCATING HIDDEN FISSURES IN RAILS, by S. I. Boone;

INDUCTION TYPE OF RELAY, by A. H. Goddins;

REMOVING SLEET AND ICE FROM TRANSMISSION LINES, by L. P. Kerwin;

VARIED USES OF THE PHOTOELECTRIC CELL, by W. C. McMillion. February 17. Attendance 27.

The following talks were given by students;

INDUCTION OF ELECTRIC CURRENT BY MICHAEL FARADAY, by P. N. Vannoy;

EARLY LIFE AND TRAINING OF FARADAY, by H. O. Webb;

FARADAY'S EXPERIMENTS, by J. E. Newcomer;

VIEWS OF FARADAY, by P. Shaff;

LIFE OF HENRY, by S. B. Wolfe;

SUMMARY OF HENRY'S CONTRIBUTIONS, by T. E. Palmer. February 24. Attendance 33.

University of Wisconsin

AUTOMATIC OSCILLOGRAPHS, by J. D. Cobin, student;

TRENDS IN ELECTRICAL CONSTRUCTION, by R. J. Nickles, Jr., student;

COPPER OXIDE RECTIFIERS, by J. L. Jones, student. Joint meeting with the Madison Section, sponsored by the Branch. February 18. Attendance 55.

ORGANIZATION AND FUNCTIONS OF THE CONSTRUCTION DEPARTMENT OF COMMONWEALTH EDISON CO. OF CHICAGO, by Theodore Racheff, Branch secretary. Short talk on the life of Faraday given by Professor C. M. Jansky, counselor. November 26. Attendance 11.

University of Wyoming

LIFE OF FARADAY, by T. Hance, student;

LIFE OF JOSEPH HENRY, by A. Bucholz, student. Election of officers as follows: N. Sanders, Chairman; T. Hance, vice-chairman; Roy Perkins, secretary-treasurer. February 10. Attendance 13.

Yale University

Films—"Blasting the Waterways of America," and "The Single Ridge." Joint meeting with the A. S. M. E. Branch. February 10. Attendance 46.

THE SIMPLER TYPES OF LIGHTNING ARRESTERS, by L. A. Autuori, Branch secretary;

THE AUTO-VALVE AND THYRITE ARRESTERS, by R. A. Hackley, student;

THE USE OF THE KLYDONOGRAPH ON POWER AND TELEPHONE LINES, by E. R. Eberle, student. February 19. Attendance 13.

Engineering exhibition held jointly with the A. S. M. E. Branch. February 23. Attendance 540.

PUBLIC UTILITIES ACCOUNTING SYSTEM, by O. C. Rutledge, student;

RATE STRUCTURES AND SCHEDULES, by A. A. Watson, student;

ECONOMIC FACTORS OF ELECTRIC POWER INTERCONNECTIONS, by H. Geers, student. February 26. Attendance 13.

BIOGRAPHY OF MICHAEL FARADAY, by F. W. Wolff, student;

TECHNICAL ASPECTS OF FARADAY'S EXPERIMENTS, by P. Thomson, student;

BIOGRAPHY OF JOSEPH HENRY, by J. D. Upton, student;

THE TECHNICAL ABILITY OF JOSEPH HENRY, by L. Clare, student. R. M. Gerris, student, gave a history of the Sheffield Scientific School of Yale University. March 7. Attendance 28.

Employment Notes

Of the Engineering Societies Employment Service

Position Available

ASSISTANT to research engineer in automotive division of large manufacturing concern. College graduate in electrical engineering with GE or Westinghouse experience on electric automotive accessories, preferred. Apply by letter. Location, New England. W-2498.

Men Available

JUNIOR ENGINEER, 1930 graduate, B. S. and E. E. degrees. Practical experience in general electrical measurements and knowledge of radio receiver construction. Desires position in electrical or mechanical engineering where technical knowledge is principal requirement, as research, design, or testing. Location preferred, in or near New York City. C-8813.

ELECTRICAL ENGINEER, graduate of European technical college, with eight years' of varied and successful research experience in the United States. At present employed. Desires responsible position in the development or consulting department of a concern located in or near New York. B-6782.

GRADUATE ELECTRICAL ENGINEER, 31, married, with seven and one-half years' experience including: two and one-half years as engineer with manufacturer's service shop, two years university instructor, two years responsible position in manufacturer's engineering department and one year as electrician on station construction. Desires position with manufacturer, industrial concern or public utility. Available on short notice. C-1073.

GRADUATE ELECTRICAL ENGINEER, 25, single. Reared in the Orient, traveled widely, one year test course with motor manufacturer, one year sales experience on Pacific Coast. Desires permanent location with a company looking forward to an expansion in its foreign business. Available at once. Location, anywhere in United States. B-6945.

CONSULTING ENGINEER with long and successful experience in development and improvement of electrical devices including specialities in signaling, lighting, regulating, and railway fields. Desires additional connections. Especially interested in manufacturers' problems regarding new products and improvement of old products. C-8843.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930. Cooperative plan, worked alternate months, five years substation maintenance and office engineering. Rebuilding transformers, switches, lightning arresters, work with electric furnaces, rectifiers, motors, etc. Checking and mapping distribution systems, work orders, drafting. Single, excellent physical condition. Desires position, preferably with utilities. Location, immaterial. C-7847.

ELECTRICAL ENGINEER, B. S. degree from recognized Southern University, 24, single. Eighteen months on power transformer test, part of which was high-voltage and other experimental test. Desires position with future. Location and salary secondary to opportunity. C-8881.

PROFESSOR OF ELECTRICAL ENGINEERING, 49, 18 years' of successful teaching experience in both d-c. and a-c. circuits and machines, and theory of transmission. Denominational college. B. E. in E. E. and M. S. degrees. Location preferred, South. B-2675.

GRADUATE ELECTRICAL ENGINEER, 1930, 22, single, seven months on Westinghouse engineering course. Desires position with company in field of electrical or physical measurements and testing. Available at once. Location, immaterial. C-8875.

ELECTRICAL ENGINEER, graduate Rensselaer Polytechnic Institute, age 33. Five years with engineering department of large manufacturer of electric control apparatus. Four years with leading engineering firm as electrical designer on central station and industrial work. Specialized on switchboard and wiring design. Some sales experience. Now employed. Desires more responsible position. B-6274.

ELECTRICAL ENGINEER, bachelor and master degrees; 14 years' peculiarly broad experience in test, research and development, standardization, consultation, university teaching, executive work, personnel; familiar with both power and radio equipment and practise. Stability and opportunity primary; initial salary and location secondary. Available at once. C-4591.

ELECTRICAL ENGINEER, 32, married. Seven years with manufacturer on design of electric traction equipment and control apparatus. General engineer. Experience writing specifications, reports, technical papers. Teacher of mathematics. C-8896.

GRADUATE ELECTRICAL ENGINEER, B. S. Degree. One and one-half years with large electrical manufacturing concern in test and research departments. Also familiar with repair work on distribution transformers and other apparatus. Available on short notice. Location preferred, New England or eastern part of country. C-8075.

PROFESSOR OF ELECTRICAL ENGINEERING, 34, eight years' experience in teaching most branches of electrical engineering, state school. Holds broadcast class, limited operator's license. Five years' experience operation and maintenance of college broadcast transmitter; B. S. in E. E. and E. E. degrees. Location preferred, East, Middle West. Available school year 1931-32. C-8916.

ELECTRICAL ENGINEER, technical graduate, G. E. test and over 18 years' varied experience, including electrical manufacture; railway construction, valuation and maintenance; power-line construction and steam railroad electrification. Desires position with company doing consultation and construction engineering or with operating company. B-7456.

PROFESSOR OF ELECTRICAL ENGINEERING, 32, married, B. S. (E. E.) and E. E. Three years with General Electric Company, five years with public utility, four years' teaching and administrative experience in state university. Excellent references. Available for next academic year. Correspondence invited. C-7152.

ELECTRICAL AND ILLUMINATING ENGINEER, 41, married, 23 years' experience, wireman to superintendent, estimator and engineer, instructor in applied electrical engineering. Experienced in power station, commercial and industrial building wiring. Six years' engineering for architects, writing specifications, designing electrical installations, office buildings, theatres, hotels, schools, hospitals, industrial buildings. C-8460.

DRAFTSMAN-DESIGNER, electrical engineer, German Technical Institute, 32, married. Eight years' foreign, three and one-half years' American experience in design of electrical apparatus and radio receivers. Desires permanent, related position. Location preferred, Newark or New York. C-8787.

ASSISTANT PROFESSOR OR INSTRUCTOR IN ELECTRICAL ENGINEERING, eight years' teaching experience in d-c. and a-c. theory, electrical machinery, radio, dynamo laboratory, and electrical measurements; four years' commercial experience in power, lighting, radio and general electrical equipment design. Available for fall term. C-6302.

GRADUATE MAINTENANCE ENGINEER, 26, married; eight years' varied experience, operating steam turbines, high-voltage a-c. remote control board, hand switching, and power-house apparatus of all kinds. Also construction and electrical maintenance work of all kinds in chemical and cement plants. Now unemployed. Will accept first reasonable offer. C-8522.

PROFESSOR OF ELECTRICAL ENGINEERING, 40, six years' successful experience teaching practically all branches electrical engineering, state school. Considerable experience power, telephone work. One year switchboard engineering department of Westinghouse; B. S. in E. E. and E. E. degrees. Prefer location, Rocky Mountain, Pacific Coast States. Available school year 1931-1932. C-5021.

1929 GRADUATE heading university, B. S. E. E., desires position giving experience cable installation. One year's experience large power company laying out underground network distribution system. One year's experience rubber-insulated cables, electrical testing laboratory large cable manufacturer. Can handle men. Working knowledge French, Spanish; elementary knowledge German. Location, immaterial. C-6408.

ELECTRICAL DESIGNER, age 36, married. Ten years' public utility experience in steam and hydroelectric plants, substations and industrial plants. Also served four years as fire insurance inspector. Graduate of technical school on electrical and mechanical subjects. C-7979.

ELECTRICAL ENGINEER, 47, college graduate, married. Twenty-six years' experience as designing, report, power and executive engineer with three engineering firms. Experience includes cost estimating for plant and transmission facilities, design, construction supervision, operating economics with fuel and hydro plants, system planning for public utility and industrial properties. B-4553.

ELECTRICAL ENGINEER, 1930 graduate, desires position. Experience in drafting, radio service, electric-meter testing. Recently technical representative for large radio-phonograph concern. Excellent references. C-8578.

ELECTRICAL DESIGNER AND DRAFTSMAN, age 31, single. Eight years' public utility experience in steam and hydroelectric plants, substations and industrial plants. Graduate of technical school in mechanical and electrical engineering. Desires position with public utility or industrial company. C-4510.

DIRECTOR OF EDUCATION AND TRAINING with national technical corporation, formerly assistant professor of electrical engineering, 5 years at leading technological college. Experienced administration educational work. Desires position professor electrical engineering, head of department at medium sized or small college where development and expansion is possible, or associate professorship in large technical college. C-8967.

ELECTRICAL-MECHANICAL ENGINEER, graduate, age 34, married. Experienced, design, manufacture and application of motors and generators. Past five years in district sales office of large manufacturer, contacting central stations and large industrial concerns both in operating problems and sales promotion. Desires a job where initiative, energy, and results will count. B-9432.

ELECTRICAL FOREMAN, 38, married. Eighteen years' experience covering power plant, substation, industrial, construction and maintenance. Have headed these departments for years. Especially qualified to take charge of actual work under a busy executive. C-2028.

ELECTRICAL ENGINEER, 31, B. S. E. E. 1926. One year assistant electrical engineer making preliminary studies, investigations on hydroelectric projects; one year engineer electrical control of armament on aeroplanes; two years material inspection, street railway company; one year student engineer large public utility; two years' electric car shop experience. C-6077.

GENERAL ENGINEER, 27, married, A. B.; and B. S. in E. E. degrees. Experienced in steam power plants, water-works, industrial electrical equipment maintenance, underground power system construction and maintenance, and oil refinery equipment standardization and maintenance. Desires engineering position along line of experience that has possibilities for advancement. Location, immaterial. C-8982.

PLANT ENGINEER, age 47, married, two children, two degrees in E. E. Over twenty years' experience in design, construction, maintenance and operation of all mechanical equipment for buildings, building construction; factory facilities, steam and hydraulic power plants. Understands efficient handling of large groups of men. Location, South, Central West or Northeast. C-8868.

ELECTRICAL ENGINEER, 36, married, university graduate. Eighteen years' experience in design, construction, maintenance and operation of hydroelectric stations, distribution and transmission systems, also design and construction of steam stations. Last five years with large consulting firm. Initiative and ability to produce. C-8980.

GRADUATE ELECTRICAL ENGINEER, 33, eight years' experience in high-voltage research. Wishes position with switch manufacturer in design work. Location, anywhere. C-8981.

ELECTRICAL ENGINEER, 25, single. Cornell University graduate in E. E. Two years' drafting experience with large engineering concern. One year in manufacturing plant as assistant to plant engineer. Desires permanent position with a future with a utility or engineering company. C-8949.

GRADUATE ELECTRICAL ENGINEER, age 23, single, 21 months of Westinghouse Test on rotating machinery and control, B. S. in E. E. 1929, at present pursuing graduate study. Desires position as engineering instructor or in any electrical line offering a future. Available immediately. Eastern Location preferred. C-8966.

SALES AND EXECUTIVE ENGINEER, trained at Worcester Polytechnic Institute. Seven years' sales experience: straight sales eneneering, jobbing sales, sales management, saels promotion. Has contacted with electrical and mechanical companies. Traveled East, Middle West, South. Well acquainted with New England. C-5431.

ASSISTANT PROFESSOR OR INSTRUCTOR in electrical engineering. Three years development and research engineer on communication apparatus. Five years head of electrical department in large industrial school. At present on E. E. staff of recognized university, teaching electrical design and other electrical engineering subjects. Available in September. C-2893.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with 8 years' industrial control, power plant design and construction supervision experience with contractor. Desires position with public utility or manufacturing concern's engineering or construction departments. Location desired, Middle West. C-4428.

GRADUATE ELECTRICAL ENGINEER, age 26, single, 4½ years' experience with Westinghouse Electric and Mfg. Co. including graduate student course and two engineering departments. Has done experimental and application work on industrial devices using electronic tubes, particularly photo-tubes. This includes some design work, technical correspondence and diagram drafting. Available early summer. C-8888.

GRADUATE ELECTRICAL ENGINEER, 25, obtaining Master's Degree in June, 1931, desires position as assistant professor or instructor in electrical engineering, or as research engineer. Four summers' employment with large utility company. Two years' teaching experience. Has had experience with development of remote-control apparatus. Available July 1, 1931. Location, United States. C-8994.

EFFICIENCY ENGINEER, industrial electrical graduate with broad experience in application of electric drive and design of complete power layout in plants. Experience also includes considerable time with power companies and refrigeration companies. Available on short notice. Location, immaterial. A-4018.

1929 GRADUATE, E. E. degree. Fourteen months on General Electric Test. Assignments covered work on radio and vacuum development and testing all types of electrical equipment. Available immediately. C-1879.

GRADUATE ELECTRICAL ENGINEER of Purdue University with 18 years' experience in design, construction, estimating, costs, valuation and appraisal of power plants, substations, transmission lines and industrial plants including five years in heavy electric traction and rapid transit work. Open for opportunity with future. C-8256.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, 36, desires connection with public utility or industrial firm on power-station operation as engineer, or as assistant to superintendent or engineer. Ten years' experience in power plant test, operation, design, construction, and maintenance. Three years electrical engineer for industrial firm. Two years assistant to power engineer. B-8379.

ELECTRICAL ENGINEER, 28, married, 4 years out, now employed. One year power utility course, three years telephone and talking pictures. Previous experience as commercial radio operator. Would be valuable to concern requiring services of capable engineer. Position must be permanent with future. Location secondary factor. Best of references available. Correspondence invited. C-7902.

ELECTRICAL ENGINEER, graduate 1931, 26 years, single. Desires position in Mexico or South America. Speaks and writes Spanish. An engineering work in radio or any electrical enterprise with opportunity for advancement is desirable. References. C-8662.

ELECTRICAL ENGINEER, B. E. E., class 1918. Two years teaching, two years sales promotion, five years design power houses, substations, transmission, equipment specification and purchases, switchboards, control, etc. Four years plant engineer. Available April 1st. C-8942.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.	205 West Wacker Drive	31 West 39th St.
San Francisco	Chicago	New York
N. D. Cook, Manager	A. K. Krauser, Manager	W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Membership

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before April 30, 1931.

Abara, L. L., Associated Gas & Electric System, Cambridge, Mass.
Arnold, J. S., Western Electric Co., Chicago, Ill.
Bailey, C. R., Wisconsin Telephone Co., Milwaukee, Wis.
Beaumont, F. E., Otis Elevator Co., New York, N. Y.
Brayman, C. E., J. J. Murphy & Son, Hartford, Conn.
Brooks, J. F., American Tel. & Tel. Co., New York, N. Y.
Caldwell, R., Idaho Power Co., Melba, Idaho
Campbell, A. T., Southwestern Bell Tel. Co., Kansas City, Mo.
Carroll, B. J., Western Electric Co., Kearny, N. J.
Carter, J., New York Edison Co., New York, N. Y.
Collins, F. H., (Member), Kansas Gas & Electric Co., Wichita, Kans.
Cory, H. M., Buffalo, Niagara & Eastern Power Corp., Buffalo, N. Y.
Crozier, C. J., New York Telephone Co., New York, N. Y.
Dare, T. J., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Deinert, C. R., Bell Telephone Co. of Pa., Pittsburgh, Pa.
Dellgren, H. F., Brooklyn Edison Co., Brooklyn, N. Y.
Downing, C. R., Public Service Co. of Okla., Tulsa, Okla.
Dunham, J. M., American Tel. & Tel. Co., New York, N. Y.
Eggertson, E. G., Safe Harbor Water Power Corp., Baltimore, Md.
Faile, E. H., (Member), E. H. Faile & Co., New York, N. Y.
Fox, E., Southern Public Utilities Co., Salisbury, N. C.
Freeland, E. L., Western Electric Co., Chicago, Ill.
Geiges, K. S., Underwriters' Laboratories, New York, N. Y.
Gonzalez, J., Power Plant, Rosita, Coah., Mexico
Harris, R. F., (Member) Heald's Engineering Colleg , San Francisco, Calif.
Hoffman, R. E., Western Electric Co., Inc., Chicago, Ill.
Holsten, F. H., Bell Tel. Labs., New York, N. Y.
Huisking, J. C., The Philip Carey Co., New York, N. Y.
Jones, E. W., Cornell University, Ithaca, N. Y.
Jones, K. B., General Electric Supply Corp., Toledo, Ohio
Katz, H., 1339 Bristow St., New York, N. Y.
Kramer, R. S., (Member), N. J. Bell Tel. Co., Newark, N. J.
Kuehne, H. A., General Electric Co., Schenectady, N. Y.
Kuhlman, E. C., Southwestern Bell Tel. Co., Kansas City, Mo.
Laitinen, A., General Electric Co., New York, N. Y.
Loy, J. M., University of Oklahoma, Norman, Okla.
Major, F.H., Allied Engineers, Inc., Atlanta, Ga.
Mecum, E. J., Chicago District Elec. Gen. Corp., Chicago, Ill.
Melhorn, N. R., Jr., American-Brown Boveri Co., Inc., Camden, N. J.
Newton, J. C., Long Island Railroad, Woodhaven Junction, Woodhaven, N. Y.
Nippes, I. S., (Member), Elliott Co., Ridgway, Pa.
Oglebay, W. J., Buffalo, Niagara & Eastern Power Corp., Buffalo, N. Y.
Patterson, W. H., Edison Storage Battery Co., Orange, N. J.
Perkins, B. B., United Sugar Companies, S. A., Los Mochis, Sinaloa, Mexico
Petrasek, R. F., Carrier Construction Co., Newark, N. J.
Quintero, R., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Robinson, T. B., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Rozelle, P. M., Western Electric Co., Inc., Chicago, Ill.
Sahagen, J., General Electric Co., Lynn, Mass.
Schirtzinger, H. A., Western Electric Co., Atlanta, Ga.
Stern, J., Western Electric Co., Kearny, N. J.
Stevens, L. J., Locke Insulator Corp., Baltimore, Md.
Stuntz, H., 366 N. 12th St., Newark, N. J.
Todd, H. F., Chicago Technical Colleg , Chicago, Ill.
Underwood, C. M., Western Electric Co., Chicago, Ill.
Wall, H. F., (Member), City of Detroit, Detroit, Mich.
Waugh, W. R., 1113 Pleasant St., Indianapolis, Ind.
Wright, R. A., Pennsylvania Railroad Co., Pittsburgh, Pa.
Total 58

Foreign

Johannessen, B. L., A. S. National Industri, Drammen, Norway
Peacock, G. M. C., Metropolitan-Vickers Electrical Co., Manchester, Eng.
Pinkney, W. H., English Electric Co., Ltd., Stafford, Eng.
Total 3

Engineering Literature

New Books

In the Societies Library

Among the new books received at the Engineering Societies Library, New York, during January are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Applications of Interferometry. By W. Ewart Williams. N. Y., E. P. Dutton & Co., 1930. 104 pp., diagrs., 7 x 4 in., cloth. $.85.——This little book provides a useful description of the various types of interferometers and explains the principles of each type. The scientific and technical applications of interference methods are pointed out, and useful lists of references are given. The work is a useful introduction to the subject for engineers and physicists.

Das Buch der Grossen Chemiker, Bd. 2; von Liebig bis Arrhenius. By Günther Bugge. Berlin, Verlag Chemie, 1930. 559 pp., illus., ports., 9 x 6 in., cloth. 32 r. m.——The development of chemistry during the last century is well covered by this collection of biographies of great chemists, from Liebig to Arrhenius. Each biography gives the salient facts about its subject and points out clearly his contributions and their effect upon the growth of the science. The reader not only learns to know the individuals, but also gets a good grasp on the history of chemistry.

Economic Control of Engineering and Manufacturing. By Frank L. Eidmann. N. Y., McGraw-Hill Book Co., 1931. 402 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.——Points out problems of engineering and manufacturing which must be solved by economic analysis and presents methods of procedure for their solution. Among the matters discussed are the choice between different types of equipment, the determination of the economy of proposed changes in equipment, processes or methods, the proper amount of materials to keep in stock, the economic effects of artificial illumination, and similar problems.

L'Évolution et le Développement des Principales Industries depuis Cinquante Ans, 1880-1930. Issued by

Genie Civil as a special number. Paris, Jules-Lefebvre, 1930. 236 pp., illus., 14 x 11 in., paper. 25 fr.——In commemoration of its fiftieth anniversary, the "Génie Civil" has issued a special number devoted to a review of the progress of engineering during the half century. Forty-two articles by eminent specialists describe developments in public works, mining, agriculture, roadbuilding, railroads, etc. The publication is a valuable historical summary.

LEHRBUCH DER BERGWERKSMASCHINEN (Kraft- und Arbeitsmaschinen). By H. Hoffmann and C. Hoffmann. 2d edition. Berlin, Julius Springer, 1931. 402 pp., illus., tables, 11 x 8 in., cloth. 24 r. m.——A comprehensive treatise upon mining machinery, which not only describes the different machines used but also discusses the mine power plant and the distribution of power. Starting with a chapter on thermodynamics, the author discusses fuels, boilers and boiler plants, piping, steam engines and turbines, and internal-combustion engines. Hoisting machinery, pumps, compressors, compressed-air machinery, refrigerating and ventilating equipment, and electrical machinery are then described.

MACHINES ÉLECTRIQUES. By A. Mauduit. 4th edition. (Électrotechnique Appliquée). Paris, Dunod, 1931. 2 v., 1738 pp., diagrs., 10 x 7 in., bound, 306,50 fr.; paper, 284,50 fr.——These two large volumes by Professor Mauduit, of the University of Nancy, treat of the theory, testing and construction of electrical machines. Both a-c. and d-c. machines are included. The subject is treated both theoretically and practically, from the plant engineer's point of view rather than for the designer.

PHYSICS. By Oscar M. Stewart. Revised edition. Boston, Ginn & Company, 1931. 770 pp., illus., diagrs., 9 x 6 in., cloth. $4.00.——A thoroughly revised edition of a popular elementary college textbook. The book is intended especially for those who are studying physics as part of a general course in the arts and sciences and have no special training in mathematics. The book aims to give a good grasp of the fundamental principles of physics, to illustrate them by everyday examples, and incidentally to train the student in the scientific method of reasoning.

RADIATIONS FROM RADIOACTIVE SUBSTANCES. By Sir Ernest Rutherford, James Chadwick and C. D. Ellis. N. Y., Macmillan Company, 1930. 588 pp., illus., diagrs., tables, 9 x 6 in., cloth. $6.50.——This new work by the famous investigator of radioactive phenomena will be welcomed by all students of the subject. It is concerned not with the transformations of radioactive substances but with the rays that accompany the transformations and the effects that these radiations produce while passing through matter. A concise, connected account of our knowledge of the radiations is given, and the bearing of the results on the problem of the structure of the nucleus of the atom is discussed.

REPORTS AND PAPERS, 1930. American Society of Mechanical Engineers Research Committees. N. Y., A. S. M. E., 1931. Various pagings, illus., diagrs., tables, 11 x 8 in., bound. $4.00.——A record of the latest achievements of the various research committees of the Society. The topics discussed include antifriction bearings, boiler metal failures, Diesel fuel oil, lubrication, management, mechanical springs, metal cutting, metal at high temperatures, thermal properties of steam and wire rope.

These papers have appeared in the *Transactions* of the A. S. M. E. and in *Mechanical Engineering*. They reappear in this volume in convenient form for preservation.

SUR L'UTILISATION DE LA CHALEUR DANS LES MACHINES A FEU. By Henri B. Reitlinger. Paris & Liége, Ch. Béranger, 1930. 254 pp., 10 x 7 in., paper. 60 fr.——An investigation of the complex phenomena involved in the operation of a thermal power plant, undertaken to develop a method by which the conditions for securing maximum efficiency of the plant, as a whole, may be determined. The author first presents the laws governing the thermostatic and thermodynamic transformations in a new form which enables him to obtain a more complete view of the utilization of the heat than can be obtained by the usual methods. He then applies the results of the method to the solution of practical problems and shows how they may be used in the design of power plants of various kinds.

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(April 1931)* Number	Author	Title
☐ 30-191	E. R. Stauffacher	Development of a Relay Protective System
☐ 31-3	J. B. MacNeill	The Trend in Development of Modern Circuit Interrupters
☐ 31-6	Malcolm Thomson	Resistance Welding of Motor Frames
☐ 31-8	J. W. Milnor	Submarine Cable Telegraphy; Influence of Interference
☐ 31-11	K. B. McEachron and E. J. Wade	Field Tests on Thyrite Lightning Arresters
☐ 31-19	S. R. Bergman	A New System for D-C. Arc Welding
☐ 31-22	H. L. Wills and O. B. Blackwell	Noise-Frequency Induction
☐ 31-23	R. N. Conwell and H. S. Warren	Low-Frequency Induction
☐ 31-35	R. M. Baker	Commutation and Current Collection in Hydrogen
☐ 31-58	A. J. Dreux and H. C. Brunner	A Modern Electrified Dairy Plant

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its JOURNAL publication. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name...

Address...

Please order reprints by number. *Address* Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.

Selected Items *From* Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Ammeters

HIGH FREQUENCY. Un Ampèremetre pour très hautes fréquences (Ammeter for Very High Frequencies). *Industrie Electrique*, vol. 39, no. 924, Dec. 25, 1930, pp. 558-561, 3 figs. Theory and construction details of hot-wire instrument measuring up to 100 million cycles; performance and correcting calculations are given.

Cables

MANUFACTURE. Aids to Better Cable Production. *Elec. World*, vol. 97, no. 4, Jan. 24, 1931, p. 197, 3 figs. Anaconda Wire & Cable Co. in production of its high-voltage cable is employing lead press specially equipped to maintain uniform thickness of lead sheath, and special facilities for determining power factor, capacity, dielectric loss, breakdown, ionization, and life of cable under cyclic loading; transformers up to 750,000 volts are used for testing.

TESTING. Cable Testing in the Detroit Edison Company, E. J. Manuel. *Elec. Light and Power*, vol. 9, no. 2, Feb. 1931, pp. 30-32, and 34, 5 figs. Cable testing in Detroit Edison Company is done with kenotron which has advantages of light weight and compactness, making it possible to mount testing equipment in truck or trailer and move hurridly to any desired location; set may be operated from either 110- or 220-volt supply; disadvantages to use of high voltage a-c. for testing purposes, are enumerated.

RADIO. Underground Circuits for the Transmission of Broadcast Programmes, A. C. Timmis and C. A. Beer. *Post Office Elec. Engrs., Jl.*, vol. 23, pt. 4, Jan. 1931, pp. 315-321, 4 figs. Essential part of Regional Broadcasting System in England now being constructed is network of land lines or repeater circuits which link up studios in London and elsewhere with radio transmitters, so that program from any studio may be radiated from all or any of transmitters; analysis of main considerations involved in faithful transmission of music under commercial conditions.

TELEGRAPH — FAULT LOCATION. Stoerungsdienst zur Beseitigung von Kabelfehlern unter besonderer Beruecksichtigung der Stoermungsbeseitigung in Verteilungskabeln beim Telegraphenbauamt Berlin, F. Glass. *Telegraphen und Fernsprechtechnik*, vol. 19, no. 12, Dec. 1930, pp. 382-387, 10 figs. System and methods are described.

TELEPHONE. Notable Telephone Developments in 1930. *Telephone Engr.*, vol. 35, no. 1, Jan. 1931, pp. 17-18, 1 fig. World communication during past year has made great strides toward giving all countries daily telephone service with each other, either by direct radio circuits or through land lines from radio terminals.

UNDERGROUND. Some Notes on Underground Cables, E. S. Simkins. *Iron and Steel Engr.*, vol. 8, no. 1, Jan. 1931, pp. 32-34. Factors controlling current carrying capacities with particular regard to properties of various insulating materials; operating temperatures of rubber, varnished cambric and paper insulation; thermal characteristics of duct structure and protection of cables after installation.

Circuit Breakers

Modern Switchgear Developments, F. G. Sublet. *Elec. Times*, vol. 9, nos. 10, 11 and 12, Oct. 27, 1930, pp. 633-636, Nov. 27, pp. 676-678, and Dec. 27, pp. 751-756, 9 figs. Functions of circuit breaker; rupturing capacity tests; oil piston theory for oil circuit breaker; recent experimental developments; electric air; air blast circuit breaker.

OIL. The Distribution of Energy Liberated in an Oil Circuit Breaker; with a Contribution to the Study of the Arc Temperature, C. E. R. Bruce. *Instn. Elec. Engrs.—Advance Paper*, received Dec. 1, 1930, 25 pp., 7 figs. Manner of dissipation of this energy is dealt with in considerable detail for various currents and for 5,500 volts (r. m. s.); energy dissipated at contact surfaces; energy radiated from arc; energy required to heat, vaporize and break up oil; energy used in raising gas to arc temperature and energy used in dissociating hydrogen present.

Condensers

MEASUREMENT. A New Method of Measuring the Capacity of Small Condensers, H. M. Barlow. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. of Science*, vol. 11, no. 68, Jan. 1931, pp. 184-193, 4 figs. One of best methods is to employ commutator to charge and discharge it with periodicity that can be accurately determined; when dealing with condensers under about 100 micro-microfarads really accurate observations are not then possible; with object of overcoming this difficulty attempt was made to employ two thermionic tubes in place of commutator, charging and discharging of condenser being controlled by alternate positive and negative potentials applied to grids.

Conductors

Temperature Rise of a Conductor due to the Electric Current, Y. Ikeda and K. Yoneta. *Hokkaido Imperial University—Faculty of Eng.—Memoirs*. vol. 2, no. 5, Dec. 1930, pp. 107-145. Mathematical analysis of temperature rise of thin wire and strip with rectangular cross section; results can be applied exactly to problem of fusion of fuse as shown in later paper in same issue; application to design of dimension of galvanometr-string and that of electric heater. (In English).

Control

MACHINE TOOLS. Control of Individually Driven Machine Tools, C. H. S. Tupholme. *Mech. World*, vol. 89, no. 2296, Jan. 2, 1931, pp. 9-10. Maximum output and greatest flexibility of operation are obtained only when motor-driven machine tools are equipped with some form of automatic control; all automatic controlling devices divided into two classes; one known as time acceleration starters, and other as current-limit starters or series relays; complete control from one point is of greatest value for many classes of work, as workman can change speed at will as best suits work as it progresses.

Culture

ENGINEERING. Engineering Culture, H. F. Moore. *Science*, vol. 73, no. 1881, Jan. 16, 1931, pp. 51-54. It is not justifiable in author's opinion to exclude from any system of general culture consideration of viewpoint, either of scientific method, or of viewpoint of applied science; is it not just to call a man uncultured who knows history and philosophy of heat engine, but is ignorant of music, while musician is hailed as cultured, who is master of his technique but contemptuous of science which has made possible modern pipe organ; some positive contributions of engineering to culture are cited. Address before Am. Assn. Advancement Science, Dec. 30, 1930.

Dielectrics

Dielectric Phenomena at High Voltages, B. L. Goodlet, F. S. Edwards and F. R. Perry. *Instn. Elec. Engrs.—Advance Paper*, received Dec. 16, 1930, 33 pp., 32 figs. Breakdown of air, oil and solid dielectrics by normal frequency, impulsive and high frequency voltage; large amount of original numerical data is given, covering entire range of voltage up to one million volts.

Economics

ENGINEERING. Engineering, Economics, and the Problem of Social Well-Being—The Engineer's View, R. E. Flanders. *Mech. Eng.*, vol. 53, no. 2, Feb. 1931, p. 99-104. Social problems presented by business cycle for solution by engineers; more complete science of economics needed; inter-relations of engineering, science and invention; work for coal engineer.

Electric Discharge

The Potential of the Walls in the Cathode Dark Space, J. W. Beck and K. G. Emeleus. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. of Science*, vol. 11, no. 68, Jan. 1931, pp. 54-64, 8 figs. Method for finding potentials in cathode dark space has recently been developed; which affords test of Morse's theory of dark space and leads to determination of Townsend's ionization for electrons; Brown and Thomson's values for these differ somewhat from Townsend's and it was thought that this might be due in part to effect of wall charges in discharge-tubes used by them; for this and other reasons it seemed of interest to undertake investigation of wall potential described.

Electric Drive

CENTRIFUGES. The Application of Electric Motors to the Driving of Centrifugal Machines. *Engineer*, vol. 151, no. 3915, Jan. 23, 1931, p. 112, 1 fig. Notes based on information supplied by Pott, Cassels and Williamson, of Motherwell, have been confined principally to induction motors which are mainly used in sugar factories and refineries, owing to provision of three-phase supply; when d-c. is used friction clutches are usually interposed between centrifugal and motor.

COMPRESSORS. Two-Speed Synchronous Motors Drive Compressors, H. E. Larson. *Power*, vol. 73, no. 4, Jan. 27, 1931, p. 138-141, 8 figs. Five synchronous-motor torques are considered in application of equipment to reciprocating compressor drives; to allow operating compressors are reduced output two-speed synchronous motor has been developed and machines of that type are now in service.

ROLLING MILLS. Main Roll Drive Statistics.—1930. *Iron and Steel Engr.*, vol. 8, no. 1, Jan. 1931, pp. 34-38. Tabulated lists of main roll drives installed in 1930 in United States and Canada; showing hp., r.p.m., voltage, cycles, type and size of mill, method of drive, date of purchase, name of plant and location.

STEEL PLANTS. Electrical Equipment for Steel Mills, H. A. Winne. *Blast Furnace and Steel Plant*, vol. 19, no. 1, Jan. 1931, p. 109-110. Data on outstanding features of mill drives installed during 1930; reversing mill drive; d-c. main drives; motor driven heavy shears.

Electric Furnace

Recent Trends in Electric Heating, G. M. Bayne. *Elec. News*, vol. 40, no. 3, Feb. 1, 1931, pp. 79-80, 1 fig. New types of highly efficient electric furnaces available for specific requirements indicate that application of electric heat-treating is only on its infancy.

Electric Furnaces: Their Development and Application, V. O. Cutts. *Metal Industry (Lond.)*, vol. 38, no. 3, Jan. 16, 1931, pp. 78-80 and 99-100, 6 figs. Economic considerations; non-ferrous metal and melting furnaces; induction furnaces for melting; adoption of electric heating never results in inferior product; it often renders possible improved product.

ALUMINUM ALLOYS. The Heat Treatment of Aluminum Alloys in the Electric Furnace. *Metal Industry (Lond.)*, vol. 38, no. 3, Jan. 16, 1931, pp. 81-82, 6 figs. Two typical alloys, 17S and 51S, are considered with view to illustrating function of heat treatment; artificial aging.

ANNEALING. Varies Annealing Temperature by Induction Regulator, R. W. Miller. *Steel*, vol. 88, no. 5, Jan. 29, 1931, pp. 38-40, 3 figs. Operation and design of electric annealing furnaces by Brown, Boveri & Co., Ltd., Baden, Switzerland; induction regulator enables voltage to be raised or lowered by 100 per cent from voltage in power line.

DESIGN. Electrothermal Processes, H. Moore. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 409, Jan. 1931, pp. 189-192. Technical advance in electric furnaces has been generally in improvement of detail and increase in size of unit; there is also marked tendency towards simplification of types; most significant advance has been rapid growth of high frequency induction furnace from small units melting few pounds of metal to furnaces melting up to one ton or more of steel in each charge.

ELECTRODE REGULATION. New Magnetic Hydraulic Electrode Regulator for Arc Furnaces, C. C. Loeb. *Iron Age*, vol. 127, no. 5, Jan. 29, 1931, p. 402-405, 3 figs. Sketches illustrate principles and operation of Tagliaferri regulator.

HIGH FREQUENCY. Typical Installations of Coreless Induction Furnaces, E. F. Northrup. *Iron Age*, vol. 127, no. 5, Jan. 29, 1931, pp. 395-399 and 447, 4 figs. Data on modern installations of coreless induction furnace for melting steel; usefulness as refining furnace and as ladle; views as to future of industrial melting. Bibliography.

Power Problems in High-Frequency Melting, E. F. Northrup. *Iron Age*, vol. 127, no. 4,, Jan. 22, 1931, pp. 318-332 and 367-368, 14 figs. Reliability and life of furnace and electric equipment; factors controlling melting efficiency and results obtained from specific installations in superheating gray iron and making different varieties of alloy steel; data on control of stirring effects.

INDUCTION. The Coreless Induction Furnace in a New Role, A. G. Robiette. *Iron and Steel Industry*, vol. 4, no. 4, Jan. 1931, pp. 125-129, 4 figs. Review of possibilities of this furnace as refining appliance; data on furnace linings; carbon removal; dephosphorization; oxidizing with ore while melting; economies of induction steelmaking.

REFRACTORY MATERIALS. Refractory Materials for Electric Furnaces, A. B. Searle. *Metal Industry* (*Lond.*), vol. 38, no. 1, Jan. 2, 1931, pp. 3-4. Melting of lead and its alloys including type of metal, babbitt metal, and solder; temperature considerations; types of brick; shapes of bricks for lining; furnace roof.

Electric Measurements

REACTIVE POWER. Méthode de mesure de l'énergie électrique (Method of Measurement of Electric Energy), N. Koppel. *Industrie Electrique*, vol. 40, no. 925, Jan. 10, 1931, pp. 14-15, 5 figs. Method outlined allows for measurement of reactive power with ordinary calibration watt-hour meter.

Elevators

ELECTRIC. Operating Two Elevator Cars in One Hoistway, H. D. James. *Power*, vol. 73, no. 3, Jan. 20, 1931, pp. 100-103, 8 figs. In first commercial installation of its kind, two cars run on same guide rails, with another set of guide rails for counterweights; each elevator car in office building of Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., rated at 3,000 lb. at 600 ft. per min.; floor-button system of control and full-automatic operation; design and operating characteristics; plan and elevation views of hoistways.

High-Speed Lifts, R. E. Hopkins. *Elec. Rev.*, vol. 108, no. 2773, Jan. 16, 1931, pp. 95-96, 2 figs. Review of two-speed problem on polyphase supply systems, with special reference to two-speed slip-ring "Equistop" motor.

Fuses

DESIGN. Rechnerische Bestimmung der Strom-Zeit-Kurve und des Grenzstromes; Beitrag zur Frage traeger Sicherungen (Numerical Determination of Current-Time Curve and of Limiting Current; Contribution to Problem of Slow-Acting Fuses), H. Vollhardt. *Elektrotechnische Zeit.*, vol. 52, no. 2, Jan. 8, 1931, pp. 37-40, 6 figs. Simple rule for graphical differentiation of exponential curves developed and correctness mathematically proven.

Mathematical Investigation of the Practical Formula on the Fusion of Fuse, Y. Ikeda and K. Yoneta. *Hokkaido Imperial University—Faculty of Eng.*—Memoirs, vol. 2, no. 5, Dec. 1930, pp. 147-159, 3 figs. Theoretical mathematical analysis. (In English).

Gases

ELECTRIC DISCHARGE. Les particularités de la décharge électrique dans les gaz rares, au point de vue de leur application a l'éclairage (Particularities of Electric Discharge in Rare Gases Considered from Standpoint of their Application in Lighting Practice), M. Laporte. *Revue Générale des Sciences*, vol. 41, no. 19, Oct. 15, 1930, pp. 543-548, 2 figs.; see also *Genie Civil*, vol. 98, no. 4, Jan. 24, 1931, p. 95, 2 figs. Contents of rare gases in air; chemical and electric considerations for use of rare gases; process in purification from lighting standpoint; spectrum of neon is most important because of its richness of red, orange and yellow rays.

Generators

WATER WHEEL. 20,000-Kva. Water Wheel Alternators, S. Neville. *Metropolitan-Vickers Gaz.*, vol. 12, no. 213, Jan. 1931, pp. 286-291, 10 figs. Two machines constructed and installed by Metropolitan Vickers Co., as initial generating plant of Waikaremoana hydroelectric power station of New Zealand have normal rating of 20,000 kva. at 0.8 power factor and are designed to B.E.S.A. specification no. 169 which provides for overload capacity of 25 per cent for two hours they have also 2 hr. rating of 25,000 kva. at 428 r.p.m.

Hoists

CONTROL. Automatic Control of Skip Hoists. *Elec. Times*, nol. 79, no. 2047, Jan. 15, 1931, pp. 119-120, 3 figs. Special features of Brookhirst switchgear equipment; comprising automatic motor starter of solenoid type, contactor type main and reversing switch, overload protective devices and isolating switch for preventing possibility of contact with "live" parts.

Hunting

SYNCHRONOUS MACHINES. Contribution a l'étude des oscillations d'un alternateur ou moteur synchrone (Study of Oscillations of Alternator or Synchronous Motor), F. Margand. *Société Francaise des Electriciens—Bul.*, vol. 10, no. 112, Dec. 1930, pp. 1302-1339, 11 figs. General equations of three-phase machine in variable condition; summary of equations for permanent state; equations for small movements around permanent state, oscillation of synchronous machine with constant excitation, etc.; theoretical mathematical analysis.

Hydroelectric

POWER PLANTS. Load and Plant Factors S. L. Kerr. *Power Plant Eng.*, vol. 35, no. 4, Feb. 15, 1931, pp. 258-260, 4 figs. Influence on operation economy; economic loading of water turbines; seasonal variation and load regulation; test efficiency compared with over-all plant efficiency corrected for gate leakage.

Insulating Materials

PAPER. Uses of Paper in Electrical Apparatus, W. H. Anderson. *Elec. Jl.*, vol. 28, no. 2, Feb. 1931, pp. 99-103, 10 figs. In manufacture of condensers paper is very thin kraft or linen tissue; somewhat heavier paper is now being wound on fine magnet wires in place of customary cotton covering; this application, though new, promises to become extensive; another class of paper generally used throughout electrical industry is for slot cell insulation in motors and generators.

TESTING ELECTRODES. Die Ausbildung von Pruefelektroden nach Rogowski (Defining Form of Rogowski Test Electrodes), C. Stoerk. *Elektrotechnische Zeit.*, vol. 52, no. 2, Jan. 8, 1931, pp. 43-45, 1 fig. For measurements and experiments on insulating materials, form of electrode as proposed by Rogowski is often recommendable; line of reasoning is given by which electrodes can be selected; graph from which form can be deduced.

Insulation

RESEARCH. Still a Long Way to Go in the Study of Insulation, W. P. Dobson. *Elec. News*, vol. 40, no. 3, Feb. 1, 1931, pp. 83-84. Research divided into three classes; first is designated "fundamental research" having as its object discovery of properties and laws of insulation based upon fundamental properties of matter; second, embraces those studies which aim to use fundamental research to build ups empirical formulas applicable to design of insulation; third division, includes practical problems of design, improvement in materials and methods of application.

Lamps

GLOW. A Three-Element Glow Lamp for Sound Recording, V. T. Braman. *Projection Eng.*, vol. 3, no. 1, Jan. 1931, pp. 19-20, 2 figs. Employment of third element in glow lamps overcomes certain difficulties heretofore experienced in sound recording.

ULTRA VIOLET. Ultraviolet Radiation from the Sunlight (Type S-1) Lamp, A. H. Taylor. *Optical Soc. Am.—Jl.*, vol. 21, no. 1, Jan. 1931, pp. 20-29, 6 figs. Sunlight (Type S-1) lamp introduced in fall of 1929 as affording means of dual purpose lighting, combining light for vision and radiation for health maintenance; electrical characteristics; spectral energy characteristics; energy distribution; operating conditions; instruments and methods of measurement; grapical representations of data; effect of blackening of bulb.

Lighting

CODES. Code of Street Lighting. *Illum. Eng. Soc.—Trans.*, vol, 26, no. 1, Jan. 1931, pp. 15-35 and (discussion) 35-38, 1 fig. Code covers status and purposes of street lighting; visibility under street lighting conditions; lighting fundamentals; classification of streets; recommended practise for light traffic, medium traffic, and heavy traffic thoroughfares, business districts, alleys, and highways.

Lines

CONSTRUCTION. Line Construction Organization Methods. *Nat. Elec. Light Assn.—Report*, no. 111, Jan. 1931, 7 pp. Policies of several representative operating companies on various phases of line construction organization and efficiency methods are reviewed; present practise in purchase of hand tools and use of power operated tools in roofing, gaining, and boring poles are analyzed; study of line crew personnel and educational methods.

SWITCHES. Pole-Top Switches Redesigned for All-Wood Construction, F. E. Andrews. *Elec. World*, vol. 97, no. 5, Jan. 31, 1931, p. 226, 2 figs. Following adoption of all wood 33-kv. line construction on system of Public Service Company of Northern Illinois problem arose in design of pole-top switches for use on these lines; with cooperation of several switch manufacturers pole-top switches have been designed in conformity with new line construction. Before Nat. Elec. Light Assn.

GROUND DETECTORS. Neon Tubes Make Inexpensive Ground Detector, H. P. Currin. *Elec. World*, vol. 97, no. 2, Jan. 10, 1931, p. 110, 1 fig. Short sections of neon tubes with porcelain insulators for supplying exciting current proved quite satisfactory in 2,400-volt detector system.

VOLTAGE CONTROL. Voltage Surveys and How They Are Made, E. S. Lincoln. *Indus. Eng.*, vol. 89, no. 1, Jan. 1931, pp. 20-23, 5 figs. Importance of proper voltage maintenance in electrical apparatus; effect of voltage variation in following equipment; d-c. and synchronous motors, heating apparatus, and lighting system; low-voltage and single-phase or three-wires d-c. systems of voltage surveys.

HIGH TENSION — DESIGN. Calcul mécanique des conducteurs et de la tension de pose des lignes a très haute tension (Mechanical Strength Calculation for High-Tension Transmission Lines), H. Roux. *Electricien*, vol. 62, no. 1507, Jan. 1, 1931, pp. 2-6, 5 figs. Equations and curves for calculation of span, sag, stresses, etc.

PROTECTION. Safeguards for Low-Voltage Electrical Supply, H. C. Graves and J. A. C. Krips. *Power Plant Eng.*, vol. 35, no. 3, Feb. 1, 1931, pp. 210-213, 7 figs. Dual power sources, automatic transfer and protected circuit breakers, time limits, convenient inspection and repair; remote control and removable breakers overcome previous limitations.

Lighting

CAR. Electric Train-Lighting Equipment, C. Coppock. *Ry. Engr.*, vol. 52, no. 612, Jan. 1931, pp. 37-40, 8 figs. Design, construction, and operating features of equipment manufactured by J. Stone and Co.; wiring diagrams. (Continuation of serial.)

Loud Speakers

Some Measurements of Loud-Speaker in Vacuo, P. K. Turner. *Instn. Elec. Engrs.—Advance Paper*, Jan. 19, 1931, 20 pp., 18 figs. Electrical impedance of moving-coil loud-speaker is measured with coil held fast with coil free, but in vacuo; under normal conditions; from basic analysis of this type of instrument, which is given briefly, it follows that this series of measurements should allow sufficient separation of its various characteristics to lead to possibility of estimating its actual performance.

Magnetic Units

La question du "gauss" (The Problem of the "Gauss"), C. O. Mailloux. *Revue Générale de l'Electricité*, vol. 29, no. 4, Jan. 24, 1931, pp. 125-132. International Electrical Commission has introduced "Oersted" as C. G. S. unit of electric field in order to end differing conceptions of Gauss unit in United States, Great Britain and other countries; author who has taken active part in 1900 in discussions at American Institute Electrical Engineers and Electricity Congress in Paris, where Gauss unit was accepted, discusses correctness of decision of International Commission.

Measuring Instruments

Electrical Measuring Instruments Other Than Integrating Meters, C. V. Drysdale. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 409, Jan. 1931, pp. 170-178. Principal items of progress since appearance of last review in June, 1928, have been development of instrument transformers with nickel-iron cores; improvement of soft iron instruments; more general employment of spring supported pivots or jewels; adaption of thermocouples and copper-oxide rectifiers to permanent magnet instruments; introduction of new forms of a-c. potentiometers; application of photoelectric cells to photometry.

Mechanical Stresses

FIXED CONDUCTORS. Phénomènes electrodynamiques dus aux courants intenses dans l'appareillage (Electrodynamic Phenomena Due to Strong Currents in Equipment), C. Bresson. *Revue Générale de l'Electricité*, vol. 29, no. 1, Jan. 3, 1931, pp. 13-30, 24 figs. Summary of basic formulas necessary for calculation of dynamic stresses resulting from conductors in defined positions; development for practical use in design of electric apparatus and equipment as to mechanical strength with respect to short-circuit effects.

Motors

RAILROAD. Le moteur de traction a courant continu en service sour tension ondulée (Direct Current Traction Motors Operating on Pulsating Voltage), K. Toefflinger. *Revue Générale de l'Electricité*, vol. 29, no. 3, Jan. 17, 1931, pp. 105-112, 7 figs. Effect of rectified current on operation of motor can be satisfactory if certain precautions are taken; means to be applied are discussed.

Compound Motors Tested on Two French Systems. *Elec. Ry. Jl.*, vol. 75, no. 2, Feb. 1931, pp. 92-93. System developed by Lievre, of Marseilles, using compound motors with series-parallel control and regeneration, shows savings of 30 per cent from similar equipment with series motors.

SYNCHRONOUS. Simplex Synchronous Motor, M. A. Hyde. *Elec. Jl.*, vol. 28, no. 2, Feb. 1931, pp. 77-80, 6 figs. Simplex synchronous motor delivers both high starting and pull-in torque with low starting current and without use of any mechanical loading device.

Networks

ALTERNATING CURRENT. Design of Secondary Distribution Systems, V. W. Palen. *Power Plant Eng.*, vol. 35, no. 4, Feb. 15, 1931, pp. 264-267, 9 figs. Economic secondary design for single-phase system serving city of about 120,000; design data and calculations. (To be continued.)

CALCULATION BOARDS. The A-C. Calculating Board Simplifies System Design, W. W. Parker. *Elec. Light and Power*, vol. 9, no. 2, Feb. 1931, pp. 28-29, 2 figs. Demand for calculating board which would accurately take into account phase angle considerations in solution of networks for relay applications and for study of voltage regulation, load. control, and stability has been met by Westinghouse Company; equipment is described.

LOAD ANALYSIS. A Few Operating Characteristics of Domestic Motors, Radio Sets and Neon Signs, A. W. Murdock. *Hydro-Electric Power Commission Ont.—Bul.*, vol. 18, no. 1, Jan. 1931, pp. 16-22, 2 figs. Attempt to analyze characteristics from two angles, namely, effect of equipment on distribution system, and effect of irregularities in system on equipment. Before Assn. Mun. Elec. Utilities.

PLANNING. System Planning for Economic Distribution Substations. *Elec. News*, vol. 40, no. 2, Jan. 15, 1931, pp. 45-46. Supplementing "A Master Plan for Sound Growth in System Expansion," previously indexed in Jan. 1, 1931 issue; article covers economic considerations necessary for establishment of new or future distribution substations; no general rules can be applied, but every factor should be allotted its true weight to arrive at best balance. From report of Nat. Elec. Light Assn.

SHORT CIRCUITS. Méthode rapide, semi-expérimentale, pour la détermination du courant de cour-circuit permanens dans un réseau quelconque (Quick Semi-Experimental Method for Determination of Permanent Short-Circuit in Any Kind of Network), G. Crivalleri. *Houille Blanche*, vol. 29, no. 167-168, Nov.-Dec. 1930, pp. 174-179, 2 figs. Method is outlined, curves for calculation are given. (To be continued.)

Oil

ACIDITY. Potentiometric Determination of Acidity in Insulating Oils, R. N. Evans and J. E. Davenport. *Indus. and Eng. Chem.—Analytical Edition*, vol. 3, no. 1, Jan. 15, 1931, pp. 82-85, 7 figs. Estimation of acidity in oils employing alkali blue procedure has been found to give more satisfactory results than A.S.T.M. procedure; in latter method, methyl alcohol should not be substituted for ethyl alcohol; electrometric titrations have been carried out on type organic acids successfully.

Paper Mills

ELECTRIC EQUIPMENT. Installation Electrique de l'Usine de Bellegarde (Ain) de la Société Anonyme des Papeteries Darblay (Electric Installation of Bellegarde Plant of the Darblay Paper Co.), A. Perrin. *Revue d'Electricité et de Mécanique*, no. 14, Nov.-Dec. 1930, pp. 19-25, 9 figs. Supply from substation at 8,000 volt, 50 cycles, transformed over seven 800-kva. transformers to 1,000 volt; drive takes place from induction motors of 240 volt ranging from 120- to 800-hp.; equipment and machinery described and specified.

Photoelectric Cells

Der heutige Stand der Forschung auf dem Gebiete der lichtelektrischen Zellen im besonderen Hinblick auf deren technische Anwendungen (Present Status of Research on Photo Electric Cells with Special Regard to Practical Application), Schroeter. *Metallboerse*, vol. 20, no. 103, Dec. 24, 1930, pp. 2805-2806. Physical fundamentals of internal photo effect, variation of conductivity, external photo effect, separation of electrons from surfaces, photo effect in gases, and variation of charging resistance; for practical application essentially exterior photo effect is of value.

Poles

PRESERVATION. New Treatment for Preserving Poles, F. S. Shinn. *Telephony*, vol. 100, no. 3, Jan. 17, 1931, p. 33. Extensive research work carried on for purpose of developing new wood preservative; zinc meta arsenite (ZMA) found to be most practical. Address before Annual convention, Ill. Telephone Assn.

Potentiometers

GLASS ELECTRODE. The Glass Electrode and Vacuum Tube Potentiometers, D. H. Cameron. *Am. Leather Chemist Assn.—Jl.*, vol. 26, no. 1, Jan. 1931, pp. 7-23. Description, disadvantages and use of glass electrode for pH determinations.

Power Factor

The Power Factor Problem. *Elec. Engr. of Australia and New Zealand*, vol. 7, no. 9, Dec. 15, 1930, pp. 327-328, 1 fig. Savings that can be made by correction; economics of situation.

Power Supply

BUILDINGS. Electric Service for Hotels and Office Buildings. *Nat. Elec. Light Assn.—Report*, no. 112, Jan. 1931, 28 pp., 27 figs. Compiled information on use of electric service to serve as guide for engineers, architects and owners of such buildings or buildings of similar character, in selecting source of electric service; report generalizes on application of purchased electric service and brings out its tangible and intangible advantages.

CAR RETARDERS. New Haven Develops Unique Power Supply for Retarders at Providence Yard, W. F. Follett. *Ry. Signaling*, vol. 89, no. 1, Jan. 1931, pp. 11-12 and 14, 4 figs. Special motor-generator in combination with storage battery reduces power consumption to 30 watts per classified car when yard is being operated at capacity; importance of automatic switching.

Radio

AERIAL TRANSPORTATION. Port and Pilot Communication by Radio Telephone, A. E. Brundage. *Airports*, vol. 6, no. 2, Feb. 1931, pp. 11-13, 3 figs. Advantages of two-way communication between plane and airport, and available equipment; map shows air transport lines equipped with radio telephone.

AMPLIFIERS. Audio Compensated Amplifier for Broadcasting and Recording Studios, J. G. Aceves. *Radio Eng.*, vol. 11, no. 1, Jan. 1931, pp. 37-38, 5 figs. New audio amplifier system which permits of compensating for improper room acoustics and for loudspeaker deficiencies.

BATTERIES. Wireless; The Real Problem, S. T. Wallace. *Telegraph and Telephone Jl.*, vol. 17, no. 190, Jan. 1931, pp. 75-76. Problem of various batteries used in radio receivers; some may consider that all-electric operation is ultimate solution to difficulty, but for present discussion this can be dismissed; it is very long way off for great majority and in many directions it has its own peculiar difficulties, evidenced even in progressively electric America, where battery operated receivers are still very much to fore; there is occasional talk of cold tubes; they are not urgently required; infinitely more pressing problem is abolition of need for high voltages.

CONDENSERS, ELECTROLYTIC. Electrolytic Condensers — Characteristics and Methods of Measurement, W. L. Dunn. *Radio Eng.*, vol. 11, no. 1, Jan. 1931, pp. 31-33, 4 figs. Engineering presentation of true action and performance of electrolytic condensers used in radio receivers.

Characteristics of Dry-Electrolyte Condensers, H. Ross. *Radio Eng.*, vol. 10, no. 12, Dec. 1930, pp. 27-28. Laboratory examination of dry-electrolyte condensers show characteristics for radio receiver operation.

FREQUENCY METERS. Ein einfacher Frequenzmesser hoher Genauigkeit (Simple Frequency Meter of High Degree of Exactness), H. Piesch. *Zeit. fuer Hochfrequenztechnik*, vol. 36, no. 6, Dec. 1930, pp. 211-217, 5 figs. Review of existing types, calibration standards; measuring equipment over wide range of frequency, absorption wave meter, performance, theoretical fundamentals, application of phenomena for measuring purposes, description of measuring arrangement with absorption circuit. Bibliography.

GENERATORS. Motor Generators, Dynamotors, and Rotary Converters for Radio Uses, E. W. Berry. *Radio Eng.*, vol. 10, no. 12, Dec. 1930, pp. 44, and 46, 1 fig. Field for a-c. tube receivers extended by installation of machine converters; types of units are described.

MEASURING INSTRUMENTS. Rectifier Type Instruments, W. N. Goodwin, Jr. *Radio Eng.*, vol. 10, no. 12, Dec. 1930, pp. 34-35, 1 fig. Practical method of measuring alternating currents of low e. m. f.'s; construction; principle of operation; accuracy; temperature errors; frequency errors; errors due to change in current density; wave form errors.

MEASUREMENTS. Common Difficulties in Receiver Measurements, R. P. Glover. *Radio Eng.*, vol. 10, no. 12, Dec. 1930, pp. 42-43, 3 figs. Dissemination of incorrect data on receiver performance causes serious servicing difficulties; method of receiver measurement; characteristics of tubes and need for tubes having average characteristics.

REMOTE CONTROL. Mechanical Remote Tuning Controls for Radio Receivers, J. C. Smack. *Radio Eng.*, vol. 11, no. 1, Jan. 1931, pp. 28-30, 5 figs. Method of solving problem of remote tuning control for broadcast and airplane radio receivers is outlined.

SHORT WAVE. Short-Wave Receiver Design, A. Binneweg, Jr. *Radio Eng.*, vol. 11, no. 1, Jan. 1931, pp. 26-27, and 30, 3 figs. Regenerative detector short-wave receiver design with experimental results, are considered; with slight change in circuit constants, operation is greatly improved.

SHORT WAVE. A Superheterodyne Receiver for Short Waves, R. W. Tanner. *Radio Eng.*, vol. 11, no. 1, Jan. 1931, pp. 22-23, 1 fig. Oscillator tuned system for high frequency radio reception, giving stable operation is described.

Railroad

ELECTRIFICATION. Railroad Electrification Brings Economies, H. L. Andrews. *Elec-World*, vol. 97, no. 3, Jan. 17, 1931, pp. 153-155, 3 figs. Pennsylvania and Reading, using 11,000 volt, 25 cycle a-c. system are outstanding for fact that initial suburban electrifications is integral part of extensive project in main line electrification; Delaware, Lackawanna & Western is initial suburban project in this country to utilize 3,000-volt d-c. system for multiple unit cars and is first steam railroad operation of any magnitude in world to rely entirely on 3,000-volt mercury arc rectifiers as conversion units; curves and tables showing economy of operation. Presented before New York Railroad Club.

SIGNALS — CENTRAL CONTROL. Results of Centralized Control on N.Y.C., J. J. Brinkworth. *Ry. Signaling*, vol. 24, no. 2, Feb. 1931, p. 52. Review of improvements in train operation effected by centralized traffic control system. Before New England Railroad Club.

SIGNALS—INTERLOCKING. Canadian Pacific Utilizes Modern Interlocking to Protect Movable Bridge, E. S. Taylor. *Ry. Signaling*, vol. 24, no. 1, Jan. 1931, pp. 24-25, 7 figs. Design and operating features of signals and signaling system employed between Sault Ste. Marie, Ont., and Sault Ste. Marie, Mich.; two-lever table interlocking machine controls bridges.

TRAIN CONTROL. Annual Report of Bureau of Safety on Signals and Train Control. *Ry. Signaling*, vol. 24, no. 1, Jan. 1931, pp. 21-23. Abstract of report by Bureau of Safety of Interstate Commerce Commission for fiscal year ending June 30, 1930; special investigations; accidents in train-control territory.

Rectifier

VACUUM TUBES. Ein gasgefuellter Kleingleichrichter mit Oxydgluehkathode (Gas-filled Small Capacity Rectifiers with Oxide Coated Incandescent Filament), M. Knoll. *Elektrotechnische Zeit.*, vol. 52, no. 3, Jan. 15, 1931, pp. 65-68, 8 figs. New types of full-wave rectifier tubes with oxide filament and argon filling of which small dimensions provide for inexpensive manufacture and long life; oscillographic testing.

Refrigeration

ELECTRIC MOTORS. The Patent Situation in Enclosed Motor Refrigeration, H. R. Van Deventer. *Refrig. Eng.*, vol. 21, no. 1, Jan. 1931, pp. 29-32, 18 figs. Term "enclosed motor" as applied to refrigerating machines has been commonly applied to unitary motors and compressors enclosed in hermetically sealed chamber; advantages and disadvantages of arrangement; résumé of patent situation.

Rotors

Coil Support Insulation for Rotor Banding, A. C. Roe. *Indus. Eng.*, vol. 89, no. 1, Jan. 1931, pp. 33-35, 9 figs. Practical discussion of coil supports, materials and methods used to prepare them to receive winding and retaining bands.

Signals

MINES. Underground Signaling with A-C. Circuits, G. Allsop. *Colliery Guardian*, vol. 142, no. 3657, Jan. 30, 1931, pp. 393-394, 2 figs.; see also *Iron and Coal Trades Rev.*, vol. 122, no. 3283, Jan. 30, 1931, p. 217, 2 figs. Suggested methods for signaling, to guard against open sparking; necessity of closing and opening bell circuit has been eliminated by employing choke-coil to vary current through system. Abstract of paper read before Midland Inst. Min. Engrs.

Spark Gaps

CALIBRATION. Sphere-Gap Calibration, S. Whitehead and A. P. Castellain. *Instn. Elec. Engrs.—Advance Paper*, received July 22, 1930, 24 pp., 24 figs. Experiments carried out at East London College upon spark over between spheres and standardization of sphere-gap as voltmeter; origin and objects of research; methods employed in measuring high voltages.

Substations

INDUSTRIAL. Substation Standardized for Small Industrials. *Elec. World*, vol. 97, no. 2, Jan. 10, p. 103, 1 fig. Typical of equipment and arrangement adopted for loop tie-in substations for relatively small industrial customers is 22-kv. Stubenville coal and mining station of Ohio Power Company; airbreak switches are installed on line sides of tap connections leading to transformers and protective equipment, and switches of this type also are interposed in advance of delta-connected transformers; station surrounded by protective industrial wire fence is used for capacities up to 1,000 kva.

REMOTE CONTROL. Midworth Distant Repeater Equipment for Electric Substation Control. *Ry. Gaz.*, vol. 54, no. 1, Jan. 2, 1931, pp. 19-20, 1 fig. System installed on Manchester, South Junction and Altrincham Railway, enabling complete control of Timperley substation maintained from Old Trafford main substation; diagram showing general arrangement of Midworth distant repeater installation; system operation.

Telephone

AUTOMATIC. Problems in Automatic Trunking—Last Contact Traffic, N. A. Hawkins *Post Office Elec. Engrs. Jl.*, vol. 23, pt. 4, Jan. 1931, pp. 272-281, 5 figs. Theoretical considerations of case of full availability and of case of grading; practical applications with examples.

CARRIER CURRENT. Full Description of Type C Carrier System, F. J. Dommerque. *Telephone Engr.*, vol. 35, no. 1, Jan. 1931, pp. 22-24, 5 figs. System accommodates three carrier channels in addition to voice current channel.

ECHO SUPPRESSORS. The New Standard Echo Suppressor, W. F. Marriage, P. R. Thomas and K. G. Hodgson. *Elec. Communication*, vol. 9, no. 3, Jan. 1931, pp. 196-202, 9 figs. International Telephone and Telegraph Laboratories have developed new type of valve echo suppressor which has been standardized by International Standard Electric Corp. and which operates entirely without moving parts and is therefore very reliable and easy to maintain.

PERFORMANCE. Rating the Transmission Performance of Telephone Circuits, W. H. Martin. *Bell System Tech. Jl.*, vol. 10, no. 1, Jan. 1931, pp. 116-131, 1 fig. Rating is discussed on basis of rate of repetitions in telephone conversations; rating method set up on this basis is being adopted in Bell System for determining and expressing data for transmission design of telephone plant.

REPEATERS. Step-by-Step Pulse Repeater P. T. Slattery. *Bell Laboratories Rec.*, vol. 9, no. 5, Jan. 1931, pp. 238-240, 3 figs. Necessity to provide some means of relaying dial, pulses at originating office is met by use of apparatus capable of receiving pulses from subscriber's dial and sending out new ones which will successfully operate switches in distant office, known as pulse repeater; various pulse repeating circuits.

Television

Progress in Two-Way Television, H. E. Ives. *Bell Laboratories Rec.*, vol. 9, no. 6, Feb. 1931, pp. 262-264, 4 figs. Optical features, which make received image quite appreciably more life-like than it appeared with any of earlier apparatus.

MULTI-CHANNEL. A Multi-Channel Television Apparatus, H. E. Ives. *Optical Soc. Am.—Jl.*, vol. 21, no. 1, Jan. 1931, pp. 8-19, 5 figs. Method developed provides image of many-fold mor image elements than heretofore, and may make easier problem of transmission over practical transmission lines; three-channel apparatus; three-electrode neon lamp used; discussion of results.

SYNCHRONIZATION. Die Synchronisierung von Fernsehempfangs-Apparaten, Insbesondere bei Verwendung der Braunschen Roehre (Synchronization of Television Receiving Apparatus with Special Regard to Application of Braun's Tube), E. Hudec. *Fernsehen*, vol. 2, no. 1, Jan. 1931, pp. 14-28, 15 figs. It is shown that perfect synchronism between image-composing and image-dissecting equipment only then is possible, when special synchronizing current is generated at receiver which is completely separated from image current.

Testing Apparatus

High-Voltage Testing Equipments, E. T. Norris and F. W. Taylor. *Instn. Elec. Engrs.—Advance Paper*, received Dec. 16, 1930, 22 pp., 26 figs. Paper describes numerous classes of apparatus available for production of high voltages for testing and experimental purposes and discussed installation and operation of complete testing equipments for various specialized requirements.

Trackless Trolleys

Trolley Bus Costs and Advantages Compared With Other Vehicles, E. H. Lamberger. *Elec. Traction*, vol. 27, no. 1, Jan. 1931, pp. 28-31, 4 figs. Advantages and disadvantages of electric, gas-electric and gas-mechanical buses; curves indicating acceleration characteristics of three types of buses; relative schedule speed characteristics of three types of buses, average engine speed of gas-electric and gas-mechanical vehicles, and power costs; table of comparative investment and operating data between trolley bus, gas-electric and mechanical vehicles.

Trolley Bus Experiences Unprecedented Growth During Past Year, C. A. Faust. *Elec. Ry. Jl.*, vol. 75, no. 1, Jan. 1931, pp. 45-48, 5 figs. Five new installations add 105 vehicles and 34.90 route mi.; with additions of 11 trolleys buses and 7.36 mi. by systems already in operation totals for industry rise to 182 vehicles and 70.05 mi.; present trolley-bus operations in United States and its possessions; table of trolley buses ordered by electric railways during 1930, totaling 116.

Transformers

DESIGN. Transformer Design, E. T. Norris. *Elec. Rev.*, vol. 108, nos. 2774 and 2775, Jan. 23, 1931, pp. 140-142 and Jan. 30, pp. 182-184, 8 figs. Jan. 23: Investigation into methods of reducing stresses in windings resulting from high-voltage surges and steep-fronted traveling waves; initial distribution of surges; results of voltage oscillation; limitation of local stresses; electrostatic shields; maximum wave-length of surges. Jan. 20: Protection of windings against surges by means of external apparatus which reduces steepness of traveling waves.

DISTRIBUTION. Distribution Transformers, E. T. Norris. *Elecn.*, vol. 106, no. 2748, Jan. 30, 1931, pp. 162-163, 4 figs. Effect of lightning surges and line insulation on reliability test; location of failures.

GROUNDING. Buried Copper Grid Affords Uniform Ground. *Elec. World*, vol. 97, no. 6, Feb. 7, 1931, p. 286, 5 figs. System used to obtain fairly consistent ground current behavior by Oklahoma Gas & Electric Company.

RELAYS. Theory and Application of Relay Systems—Transformer Protection, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 2, Feb. 1931, pp. 111-116, 21 figs. In applying differential relays to transformers, ratio differential type rather than ordinary overload type of relay should be used; this results in form of protection which is sensitive to internal faults yet insensitive to short-circuit currents flowing through transformer and caused by external fault conditions.

TAP CHANGERS. Transformers Tap Changing on Load. *Engineer*, vol. 151, no. 3913, Jan. 9, 1931, pp. 58-59, 7 figs. New B. T. H. inexpensive and simple equipment, developed for use with transformers carrying but small current per phase, which at present can be used on transformers up to 6,000-kva. capacity and working on 33,000-volt systems, consists essentially of oil-immersed drum controller, fingers of which make contact on their segments in correct sequence as drum revolves.

Vacuum Tubes

TELEPHONE. Vacuum Tube Theory and Practise as Applied to the Telephone Circuit. *Telephone Engr.*, vol. 35, no. 1, Jan. 1931, pp. 36-38, 8 figs. Types; theory of operation; characteristic curves; constants; plate resistance; mutual conductance.

THYRATRON. Motor Control by Thyratron Tubes, A. G. Turnbull. *Elec. News*, vol. 40, no. 2, Jan. 15, 1931, pp. 64-65, 4 figs. Two examples, illustrating accurate control, point to no limit in application.

Voltmeters

NEON TUBE. The Construction and Operation of a Simple Neon-Tube High-Tension Crest Voltmeter, L. E. Ryall. *Instn. Elec. Engrs.—Advance Paper*, received July 4, 1930, 7 pp., 8 figs. Principles governing design of neon tube crest voltmeter; precautions necessary to secure reliable operation including selection of permanent neon lamp; 150-kv. (max.) crest voltmeter; and design of voltmeters for higher voltages.

Watt-Hour Meters

MAXIMUM LOAD. Hoechstleistungsmesser und ihre Messgenauigkeit (Maximum Load Meters and Their Exactness in Measuring), F. Bergtold. *Elektrische Betrieb*, vol. 29, no. 1, Jan. 15, 1931, pp. 1-5, 10 figs. Determination of maximum required load by means of watt-hour meter with special recording mechanism, performance of this equipment and possible errors in operation.

TESTING. Permanence of Rotating Standard Accuracy, G. E. Meredith *Elec. World*, vol. 97, no. 4, Jan. 24, 1931, p. 188, 1 fig. Out of 212 weekly tests on rotating standard purchased in 1924 by Kansas City Power & Light Co. and in continuous use since that year only 25 show accuracies "as found" above 100.5 or below 99.5 per cent. Before Nat. Elec. Light Assn.

Welding

BRIDGE CONSTRUCTION. Welding in Bridge Work. *Ry. Eng. and Maintenance*, vol. 27, no. 1, Jan. 1931, pp. 42-43, 1 fig. Bridge and Building Assn. considers application of electric welding steel structures; presentation of paper, strengthening a Bridge by Arc Welding Process, by W. R. Roof, and discussion.

CAST IRON. Pure-Iron Electrodes for Welding Cast Iron, H. D. Lloyd and J. S. G. Primrose. *Foundry Trade Jl.*, vol. 44, no. 752, Jan. 15, 1931, pp. 37-38. Effect of phosphide eutectic; mechanical strength of welds; burning-on; thermit process; metallic-arc method; soft-iron rods; welding gas-engine bedplate; fluxes used; danger zones; welding malleable castings. Abstract of paper read before Instn. Welding Engrs.

NICKEL STEEL. Abstract of Thesis on Arc Welding of Nickel Steel, T. K. McManus. *Am. Welding Soc.—Jl.*, vol. 10, no. 1, Jan. 1931, pp. 16-19, 5 figs. Welds in 3½ per cent nickel steel with commercial, chrome-nickel, aluminum-bronze, nickel-steel and chrome-molybdenum wire; tension, bend, impact and fatigue test of original and welded materials supplemented by *H*-ray examination; microphotographs illustrate crystal structure of welds.

PRESSURE VESSELS. Unfired Pressure Vessels, W. Spraragan. *Indus. and Eng. Chem.*, vol. 23, no. 2, Feb. 1931, pp. 220-226, 8 figs. Fundamental factors considered are: (1) selection of material of good welding quality and use of good welding wire; (2) correct design of vessel and welded joints; (3) use of qualified welders; (4) proper preparation of material for welding (5) employment of proper technic; and (6) testing of completed vessel.

Welding Machines

Resistance Butt Welding of Tools. *Welding Engr.*, vol. 16, no. 1, Jan. 1931, pp. 41-42, 5 figs. Design and performance of machines suited particularly for welding of drills and other precision tools.

AUTOMATIC. Automatic Arc Welding. *Engineer*, vol. 151, no. 3915, Jan. 23, 1931, p. 100, 5 figs. A. E. G. system of automatic arc welding was developed to improve upon welding by hand, which presents several well-known disadvantages; automatic machine can weld with higher current values and at greater speeds, while arc can be moved over work uniformly and be made to deposit metal smoothly and continuously; examples of A.E.G. welding machines and their application.

Industrial Notes

H. W. Clough Promoted.—The Belden Manufacturing Company, Chicago, announces the appointment of H. W. Clough as sales manager. Mr. Clough has been with the company for nine years and was previously manager of the Merchandise Division.

Joins Norma-Hoffmann Sales Force.—John W. Blackford, for the past 8 years with the Torrington Company and for the last two years manager of the Detroit office of the above company, has joined the sales organization of Norma-Hoffmann Bearings Corporation, Stamford, Conn.

Rockbestos Products Corporation, New Haven, Conn., manufacturers of electrical wires and cables for use under severe conditions, announces the appointment of Malcolm T. Ritchie as New England territory salesman; the addition to its Pittsburgh sales office of Carleton W. Fletcher, formerly of the main office, and the addition of Philip O. Weston to the home office sales promotion staff.

The General Electric Company, Schenectady, N. Y., has disposed of its trolley line material business to the Ohio Brass Company of Mansfield, Ohio. This includes overhead materials for electric railways, electrified mines, industrial haulage, and electrified steam roads,—a field in which the Ohio Brass Company has specialized quite intensively for many years. This transaction is relatively of small importance because of the volume of business involved, and although of some advantage to both companies, it is principally of benefit to the users of this class of material.

The Daven Company, successors to The Daven Radio Corporation, manufacturers of Super-Davohm wire wound precision resistors, 158-160 Summit Street, Newark, New Jersey, announces the purchase of the Superior Resistor Corporation recently located at 334 Badger Avenue, Newark. The entire equipment of the former Superior Resistor Corporation has been moved and assembled at the Daven plant. With this addition in machinery and equipment The Daven Company has increased its production capacity over 25 per cent. The Daven Company will retain the trade name "Super-Ohm" in addition to their present trade names "Super-Davohm" and "Davohm."

General Electric Annual Report.—Despite the general depression in business, General Electric had a fairly successful year in 1930, with earnings greatest in the history of the company, except for 1929, Gerard Swope, president, disclosed in the annual report of the company recently made public.

Orders received during 1930 amounted to $341,820,312, compared with $445,802,519 in 1929, a decrease of 23 per cent, and unfilled orders at the end of the year totalled $56,062,000, compared with $94,623,000 at the close of 1929, a decrease of 41 per cent. Sales billed for 1930 were $376,167,428, compared with $415,338,094 in 1929, a decrease of 9½ per cent. Net income from sales in 1930 amounted to $40,450,261, which, compared with $49,395,896 in 1929, shows a decrease of 18 per cent. These figures for 1930 do not include radio set and tube business, which was transferred to the Radio Corporation of America on January 1, 1930, except that derived from General Electric radios, which were introduced the latter part of the year.

The average number of employees during 1930, not including those of associated companies, was 78,380, compared with 87,933 in 1929. The total earnings of these employees were $140,905,000 and $163,090,000, and average annual earnings were $1,798 and $1,855 respectively.

Recent Westinghouse Orders.—As a part of the electrical equipment for one of the largest electro metallurgical plants in the world, the Westinghouse Electric & Manufacturing Company has received from the Electro Metallurgical Company, an order amounting to approximately $100,000 for six 5,000 kva. transformers to supply power to electric furnaces. The new plant, which will be at Boncar, West Virginia, is being constructed by the Electro Metallurgical Company, a subsidiary of the Union Carbide & Carbon Corporation.

Other recent orders include the electrical equipment for five 400-hp. gas electric cars to be used on the Santa Fe Railroad. These cars will be duplicates of four others ordered by the same company in 1929. The Westinghouse Electric International Company has been awarded a contract for twelve circuit breakers by Ryobi Denki Shokai, of Japan, for use in the Tokyo district.

An order in excess of $500,000 has been received from the Navy Department for the main propelling machinery and engine room auxiliaries for a new 10,000-ton Treaty cruiser. The new vessel, designated as No. 38, is yet unnamed and will be built at the Mare Island Yard, California. Her four main geared-turbines will deliver a shaft horsepower of 107,000, giving the vessel a speed of 33 knots. The electrical equipment will be a duplicate of that ordered for cruisers 37, 34, and 36, all being for Westinghouse machinery.

The Brooklyn Edison Company has ordered sixteen 1,000-hp. electric motors to be installed in the Hudson Avenue Generating Station as a part of the auxiliary equipment for units in that station.

Trade Literature

Instruments.—Catalog 211, 188 pp. Describes Westinghouse instruments, relays and electronic devices. Westinghouse Electric & Manufacturing Company, East Pittsburgh.

Electric CO_2 Meters.—Catalog 3004, 32 pp. Describes Brown CO_2 indicating and recording meters used in furnace operation. The Brown Instrument Company, Philadelphia.

Carrier-Current Telephone Equipment.—Bulletin GEA-1354, 8 pp. Describes type KCA-400 carrier current telephone equipment for patrol and unattended-substation use. General Electric Company, Schenectady, N. Y.

Lightning Arresters.—Bulletin 1, 20 pp. Describes the process of manufacture of crystal valve lightning arresters. This booklet is the first of a series. Electric Service Supplies Company, 17th & Cambria Streets, Philadelphia.

Oil Drier and Filter.—Bulletin GEA-1333, 4 pp. Describes the G-E transformer-oil drier and filter for removing moisture and other foreign material from insulating oil in order to restore its dielectric strength. General Electric Company, Schenectady, N. Y.

Industrial Control.—Catalog 5016, 24 pp. Describes Condit air circuit breakers, oil switches and circuit breakers, air and oil motor starters and service switches. Condit Electrical Manufacturing Corp., Hyde Park Station, Boston.

Heavy - Duty Test Sets.—Bulletin 1133, 4 pp. Describes special transformers and test sets for heavy-duty testing at high voltages. The units covered range in size from 2 to 500 kva., and are built for potentials from 10,000 volts to 300,000 volts. American Transformer Co., 177 Emmet Street, Newark, N. J.

Portable Oil Test Set.—Bulletin 1132, 2 pp. Describes a portable set for making accurate dielectric strength tests on transformer oil. The unit operates from 110-volt, 60-cycle circuits and develops potentials up to 30 kv. It is equipped with a voltmeter, circuit breaker and potentiometer. American Transformer Co., 177 Emmet St., Newark, N. J.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50

No. 5

The JOURNAL of the A.I.E.E. for May 1931

WILLIAM S. LEE, *President*
F. L. HUTCHINSON, *National Secretary*

Publication Committee

W. S. GORSUCH, *Chairman*
H. P. CHARLESWORTH E. B. MEYER
F. L. HUTCHINSON A. E. KNOWLTON

Publication Staff

GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second-class matter at the N. Y. Post Office, May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

OPINIONS expressed or statements made in ELECTRICAL ENGINEERING are not necessarily endorsed by the American Institute of Electrical Engineers; correspondence on controversial matters is invited at all times.

REPUBLICATION from ELECTRICAL ENGINEERING of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index.

Printed in the United States of America.

ELECTRICAL ENGINEERING enjoys the largest circulation in the electrical field. Number of copies printed this issue—

24,750

This Month—

Front Cover—"Arizona"

110-kv. line of the Salt River Valley (Arizona) Water User's Association which ties the 33,000-kva. Horse Mesa hydro plant into a transmission loop which includes the power house at the famous Roosevelt Dam. David F. Wilkie (A'22), superintendent of power plants is standing by the tower.

—Electrical West Photo

Stroboscopic Moving Pictures 327
H. E. EDGERTON

D-C. Power for Industrial Plants 329
R. D. ABBISS & D. C. WEST

Some Factors Affecting Stability 332
W. A. MERRIAM & H. R. ARNOLD

A High-Speed Submarine Cable 337
J. W. MILNOR & G. A. RANDALL

Noise—A Factor in Machine Design and Operation:

Difficulties in Measuring Machine Noise . . . 340
B. F. BAILEY

A New Meter for Noise Analysis 342
T. G. CASTNER, E. DIETZE, G. T. STANTON & R. S. TUCKER

Magnetic Noise in Synchronous Machines . . 344
Q. GRAHAM, S. BECKWITH & F. H. MILLIKEN

Elastic Supports for Rotating Machinery . . 347
E. H. HULL & W. C. STEWART

— Turn to Next Page —

Measurement of Machinery Noise 349
H. B. Marvin

Mitigation of Substation Noise. 351
E. A. Bishop

Noise from Induction Regulators 352
J. P. Foltz & W. F. Shirk

Impulse Tests Made on Substations 354
R. N. Southgate, A. S. Brookes, E. R. Whitehead & W. G. Roman

Automatic Arc Welding 358
G. H. Koch

Percentage Differential Transformer Protection . 361
R. E. Cordray

Automatic Speed Regulation 363
J. H. Ashbaugh

Interchange of Industrial Power for Better Operating Efficiency 365
W. B. Skinkle

Short Items—

Determining the Flexibility of Mica Sheets . 336
Metal-Clad Synchronous Motors for Nitrate Plants 339
Artificial Sunshine for the Modern Office . . 357

News of Institute and Related Activities ◆ ◆ ◆ ◆ **368**

Local Institute Meetings 380
Employment Notes 387
Membership 389
Engineering Literature 390
Industrial Notes 396
Officers and Committees
(For complete list see pages 81-84 of the January 1931 issue)

OF PARTICULAR interest in this month's news are the complete program outline for the annual Summer convention to be held in Asheville, N. C. in June (*pp. 368-371*); a review of the discussion which transpired at the recent district meeting in Pittsburgh (*pp. 372-3*); notice of an economic conference to be held in August at the engineering camp of Stevens Institute of Technology (*p. 373*), and a report upon living conditions in Russia. (*pp. 374-5.*)

B. F. BAILEY, besides having been professor of electrical engineering at the University of Michigan for the past eighteen years, has been a director and consulting engineer for several electrical manufacturers; also an expert patent case witness. He is the author of many books and articles on technical subjects; in this issue he describes some of the noise abatement work carried on at the University under his direction and introduces a symposium on the importance of noise reduction in electrical machinery. (*See p. 340.*)

THE NOISE PROBLEM is broadly treated in six other articles by four engineers of the Bell Telephone System, five of the Westinghouse Company, three of the General Electric Company, and one of the Commonwealth Edison Company, Chicago; each contributes the results of experience gained in his own particular field. (*See pp. 342-352.*)

J. W. MILNOR, for the past twelve years research engineer for Western Union Telegraph Company, and one of the foremost telegraph engineers in the entire world, gives some of the features of design and operation in connection with the New York-Azores high-speed submarine telegraph cable installed in 1928 and ever since then in successful duplex operation. G. A. Randall of the same company assisted Mr. Milnor in preparing this article. (*See p. 337.*)

INDUSTRIAL-UTILITY interconnection problems, one of the subjects to which an entire session was devoted at the recent district meeting at Pittsburgh, are discussed, and advantages accruing to both systems from a free interchange of power interestingly pointed out, by W. B. Skinkle of the Subsidiary Companies, U. S. Steel Corporation. (*See p. 365.*)

Stroboscopic Moving Pictures

By means of moving pictures taken stroboscopically it is possible to see the rotor of a synchronous machine just as though one were actually revolving at synchronous speed with the rotating field of the stator windings. Newly developed thyratron tubes provide sufficient light for taking the pictures.

By H. E. Edgerton

Associate A. I. E. E.

Massachusetts Institute of Technology
Cambridge

OF THE SEVERAL different methods of determining the very important, but rarely measured angular displacement of a synchronous machine, stroboscopic observation is the most direct and straightforward. This method requires a minimum of apparatus; namely, a disk rigidly attached to the shaft of the synchronous machine, a suitable stationary scale for recording the displacement, and an intermittent light source operating in time phase with the terminal voltage of the machine. The disadvantage of the stroboscopic method in the past has been that the measurements had to be recorded visually, and thus the accurate measurement of transient variations of angle has been practically impossible because of the inability of an observer to record the phenomena during the short duration of most transients.

With the stroboscopic device described in this article, enough light is produced so that a motion-picture record can be made of the angular displacement of a synchronous machine. A mercury vapor arc is used which produces the characteristic blue light well known for its powerful actinic properties. The tube used to produce the arc is a thryatron containing grids that control the electrical transients which are the source of the stroboscopic light.

Stroboscopic moving picture records will provide important observations for those who are concerned with the operation of synchronous machines. These moving pictures will be especially valuable when correlated with oscillograms taken simultaneously. The "strobograms," as these pictures may be called, will furnish power engineers with information regarding the angular displacements of their generators, condensers, and lines during switching and short-circuit disturbances. They will tell the users and designers of synchronous motors exactly how far the rotors swing, their period of motion, and the damping of their oscillations for violent, sudden load changes such as are common in the steel industry. Photographic records will be valuable also in studying the steady-state time-angle variations.

In addition this method of photographing stroboscopically illuminated objects will provide research workers with the means whereby many experimental investigations may be made. It is especially adapted for studying the motion of mechanical objects such as springs, cams, valves, and other devices.

Among the important requirements for a stroboscope suitable for photographic purposes, are:

1. Short duration of the light. If the illumination extends over an appreciable period of time the image will be blurred. A rough calculation shows that the duration of the main flash should not be longer than about 10 microseconds.

2. Rich actinic light. Photographic film is much more sensitive to ultra-violet and blue light than to red. For this reason a mercury discharge tube is used in place of the commonly used neon tube. The light from a mercury arc is composed of strong blue and ultra-violet colors. Some of the ultra-violet radiations are, however, absorbed by the glass walls of the tube.

3. Reliability of light-flash control. A synchronously rotating object viewed by a stroboscope will not be stationary if there is any variation in the interval of time between discharges in the stroboscope circuit. This time interval can be controlled very accurately by applying sufficient voltage to the thyratron grid.

THYRATRON CIRCUIT

An arrangement of apparatus capable of producing a powerful stroboscopic light is shown in Fig. 1. Current waves for various branches of the circuit are included also in this illustration. Light is obtained from a condenser discharge through the thyratron tube; and since the only impedance in the circuit besides the thyratron is that of the leads connecting the tube to the condenser this discharge is very rapid, lasting only about 10 microseconds or even less. An intense momentary light flash is thus obtained.

The sequence of events through a cycle of operation will be described in detail. When the grid is negative no current is flowing from the main anode because the grid has the property of extinguishing the arc. Such grid action is contrary to the usually explained rules of thyratron operation but occurs here because of the low density of the anode current and the large condenser in parallel with the arc. During this half cycle, current flows from the 500-volt d-c. source through the resistance into the condenser in the well-known exponential relationship. The resistance and capacity are adjusted so that the potential across the condenser becomes practically 500 volts during the half cycle that the grid is negative. Replacing the resistance *R* with inductance *L*, or using both in series with the condenser, will give a still higher voltage across the condenser, if *R*, *L*, and *C* have proper values.

At the end of the charging half cycle, the grid becomes sufficiently positive to allow current to flow from the anode. The charge that has been accumulated in the condenser will then be discharged through the tube. If short, heavy-stranded leads are used to connect the condenser to the tube the holding arc may be extinguished at this time by the condenser discharge, but this difficulty may be overcome by introducing a choke coil into the holding circuit and a small resistance in series with the condenser. From a recent study by Krug, (of the arc striking speed of a mercury arc rectifier), (*Arch. f. Techn. Physik 11*, 1930, 6 p. 227, and *E. u. M.* 48, June 8, 1930, p. 567), it is known that only 0.01 to 0.1 microsecond is required to start the arc. Thus the thyratron acts virtually as a short circuit across the condenser.

For the remainder of the half cycle following the condenser discharge the grid is positive and the main anode carries a current which is limited in value by the resistance *R*. The light from this current is not intense and is negligible in comparison with the condenser flash. With the pool-type of thyratron this current is oscillatory under some conditions, giving faint ghosts trailing behind the main discharge. A negative bias and a peaked a-c. voltage on the grid eliminates these oscillations.

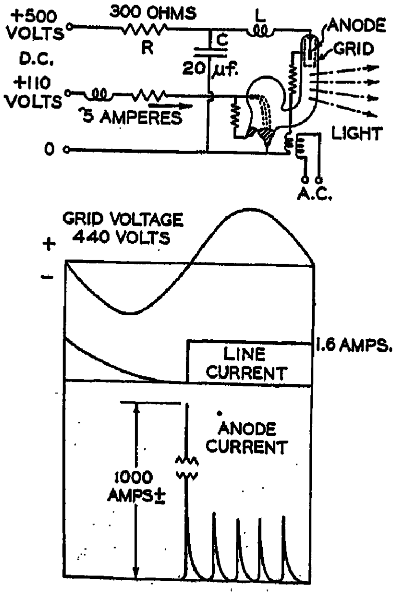


Fig. 1. Schematic diagram of thyratron circuit; voltage and current relations in various parts of the circuit are shown below

At the completion of the operating cycle the grid again becomes negative thereby extinguishing the anode current. The condenser then begins to accumulate a charge for the next flash.

STROBOGRAMS TAKEN

With the thyratron and other apparatus just described, a 160-hp. synchronous motor was photographed stroboscopically as it pulled into step. The tube was hung on a framework so that its light would fall directly upon the field structure. White cardboard collars were tied around the poles and alternately marked "*N*" and "*S*." The amortisseur rings were painted white and the protruding bars black. A general view of the arrangement in operation is shown in Fig. 2.

Strobograms taken during the transfer from operation on half voltage, which was used for starting the motor, to full voltage, are shown in Fig. 3. These consist of a sequence of enlarged, 16-mm. moving picture frames and were taken on panchromatic film at 16 frames per sec. with a lens opening of f-1.9.

The particular thyratron used for these tests had two anodes, each was connected to a circuit such as shown in Fig. 1 but the grids were supplied from a common transformer. No apparent difference in the time of discharge was experienced, except when the tube was cold.

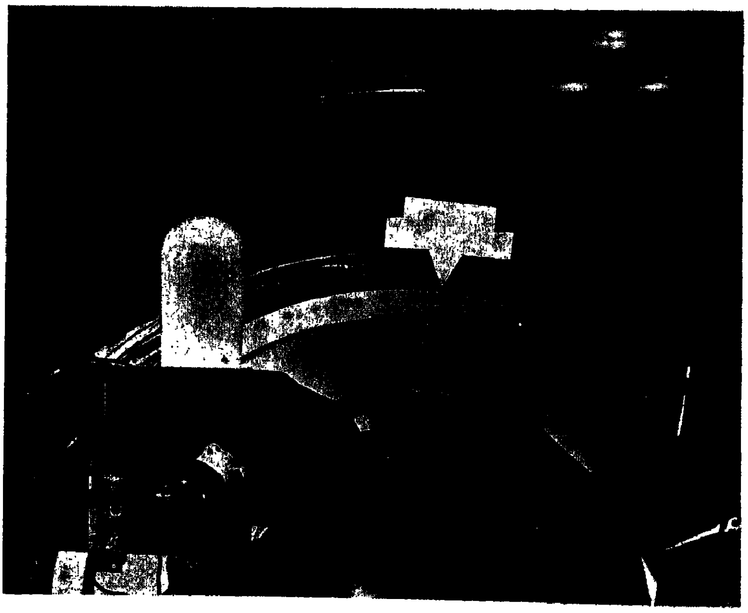


Fig. 2. Thyratron arranged for taking stroboscopic movies of a 160-hp. synchronous motor

A special camera which would record the rotor displacement angle for each cycle could easily be made. This camera would require no shutter and no mechanical framing movement. The film could be run through the camera at a constant speed and just fast enough so that the exposures would be spaced correctly.

A simultaneous reading of time could also be taken with the angle on the strobograms by photographing a clock hand driven by a telechron clock motor running at one revolution per second. This would be quite necessary for accurate testing since there is no definite relation between the frequency of the camera shutter and that of the intermittent light.

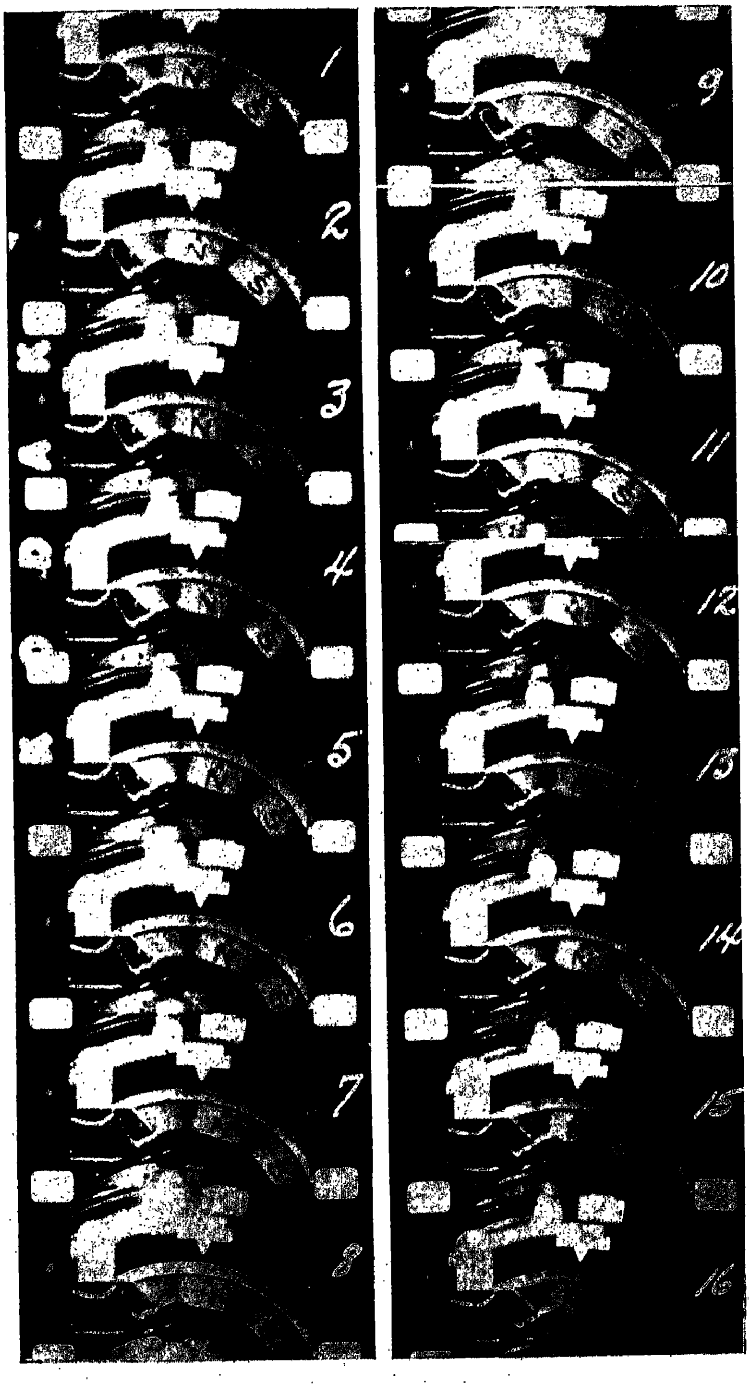


Fig. 3. "Strobograms" of a synchronous motor as it was switched from half to full voltage. Increased angular displacement may be noted as the supply switch was momentarily open during changeover (4-7)

D-C. Power for Industrial Plants

Many large industrial plants depending upon d-c. power for machinery and process operation can ill afford to continue to overlook the economies of modern a-c.—d-c. conversion apparatus and decentralized d-c. supply.

By R. D. Abbiss
Non-Member
Carnegie Steel Company
Pittsburgh, Pa.

D. C. West
Member A. I. E. E.
Westinghouse Elec. & Mfg. Co.
Pittsburgh, Pa.

IN THESE DAYS of 200,000-kva. turbine-generators, 90,000-kva. transformer banks, 220-kv. transmission lines, and the many other spectacular achievements in the electric power field, it is only natural that there has been acquired the habit of picturing the electrical industry almost entirely in terms of alternating current. It is a common failing to overlook the fact that hundreds of thousands of less spectacular devices go quietly and unobtrusively about the business of consuming at least one-quarter and probably one-third of the total production of electric energy in the form of direct current. Dominance of the polyphase a-c. system rests on the very solid foundation of fundamental economy and flexibility in generation, transmission, and distribution, together with the sturdy simplicity of the induction motor. However, direct current retains a prominent and apparently permanent place in the field of utilization because of its necessity in electrolytic work and because the flexibility of speed control inherent in the d-c. motor is of such great value in many applications. To realize these advantages of both a-c. generation and d-c. utilization it is necessary to pay the price of providing and operating a system of power conversion and low-voltage d-c. distribution. Thus an intermediate system, an additional overhead, is imposed by these differing methods of production and consumption of electrical energy.

Now in this, as in any case, the ultimate problem of the engineer is to reduce the over-all cost to a minimum consistent with adequate and reliable service. In many systems there is need for service improvement as well as cost reduction. Experience has shown that in the field of power conversion and d-c. distribution, both results can be realized by essentially the same means and methods. Much time and effort expended over a

---

From "Conversion and Distribution of General-Purpose D-C. Power in Large Industrial Plants," presented at the A. I. & S. E. E. session held jointly with the A. I. E. E. Middle Eastern District meeting, Pittsburgh, Pa., March 13, 1931.

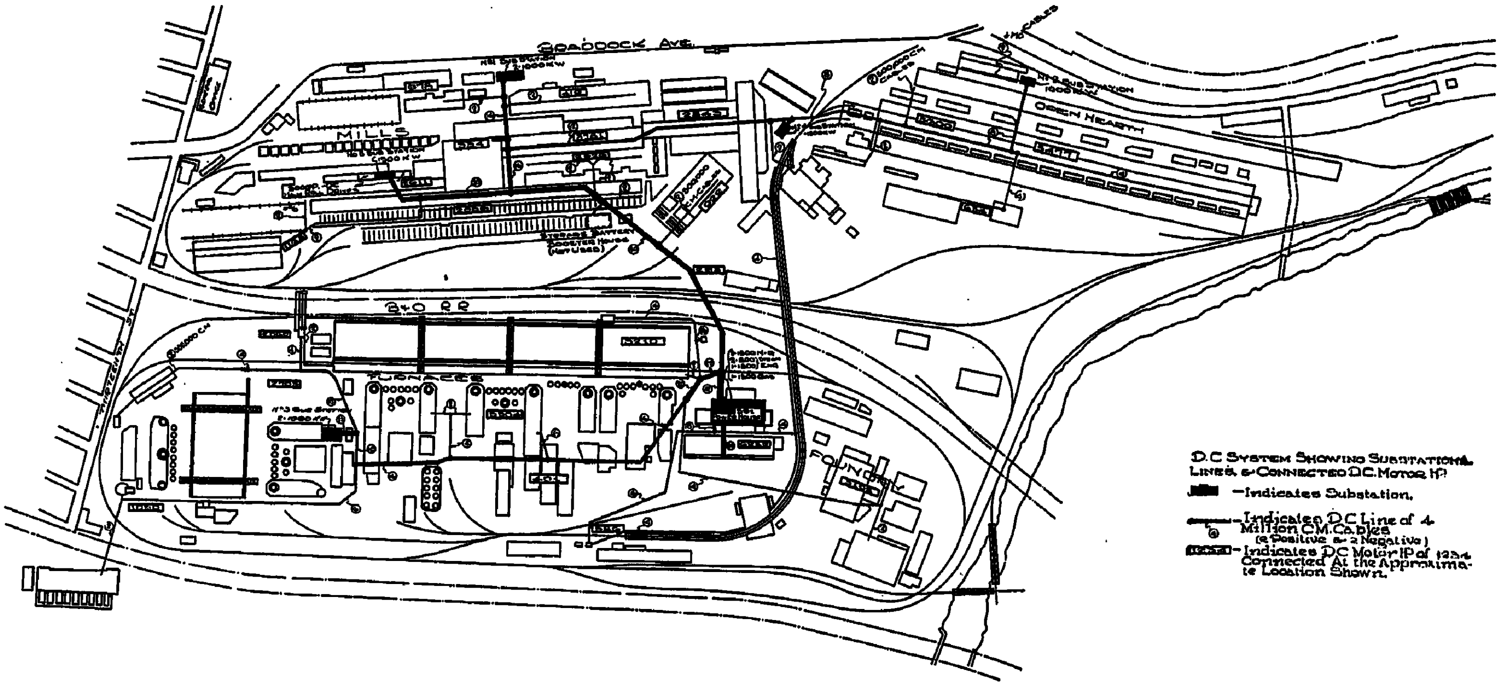

Scaboock Ave.
Mills
B&O R.R.
Furnaces
Foundry
Open Hearth
D.C System Showing Substations Lines & Connected D.C. Motor HP
—Indicates Substation.
—Indicates D.C Line of 4 Million C.M. Cables (2 Positive & 2 Negative)
—Indicates DC Motor HP of 1234 Connected At the Approximate Location Shown.

Fig. 1. Plan of Edgar Thomson works of the Carnegie Steel Company, Pittsburgh, showing d-c. power system

period of years has brought the apparatus for such a system to a high state of development; however, it probably has not been fully appreciated that the economy and improved operation which this modern equipment make possible can be realized fully only through careful planning and proper coordination of the whole system. It is the purpose of this article to bring to the attention of the industry the benefits to be derived through modernization, to state the problem and outline the procedure of system study, to point out the major engineering and economic considerations involved, and to illustrate by describing the evolution and present arrangement of a typical large system.

In the early days of the electrification of industry d-c. power was supplied to a large extent by low-speed engine-driven d-c. generators. Even today many of these elephantine machines are in regular operation, consuming a large amount of energy in the form of losses, requiring a large force of men for operation and maintenance, and taking up an excessive amount of more or less valuable space. In such cases marked economy usually can be effected by changing over to a-c. power supply and modern, high-speed efficient conversion equipment. In certain cases where process steam otherwise would be wasted, high-speed turbine-driven d-c. generators can be used to advantage.

The development of reliable and efficient conversion equipment was an important step forward, but for many years constant operating attendance was necessary at each substation because only manually-operated switching equipment was available. As a result of many large industrial plants having grown up under the limitations imposed by engine-driven d-c. generating equipment and manually-operated conversion equipment, it is not uncommon to find the total d-c. capacity concentrated into one or two large stations, although a large part of the d-c. power must be used at remote parts of the plant. Such an arrangement probably represented good economic practise at the time it was installed; however, a study will show usually that growth of the plant and the development of new apparatus have effected a marked change, and that the present-day result is a rather costly compromise between high distribution loss, low voltage at the load, and an excessive amount of distribution copper.

With the advent of completely automatic and unattended operation of conversion units it became economically feasible to distribute the d-c. substation capacity throughout the system. The average d-c. feeding distance thus is greatly reduced with a corresponding decrease in distribution cost. The saving can be taken in the form of less copper, reduced losses, or both. If improvement in voltage at the load is necessary the advantage gained can readily be turned to that purpose. It is of course necessary in any case to transmit approximately the same amount of power over about the same distance from the a-c. source to the distributed d-c. load. The fundamental economy lies in the fact that, with distributed conversion equipment, the bulk distribution of this power is over a relatively high-voltage three-phase circuit, say 6.6-kv., instead of over a 250-volt d-c. circuit.

There are other advantages to be derived from the use of automatic equipment which, although more or less intangible and difficult of exact evaluation, are important and valuable. Automatic switching equipment provides a nicety of sequence and a fundamental correctness of all switching and control operations which cannot be expected under manual control. Experience in a wide variety of applications has demonstrated that this results in a higher standard of service reliability, freedom from long and expensive outage, and greater flexibility of system operation.

The Edgar Thomson works of the Carnegie Steel Company provides a typical example of a completely automatized system of d-c. power supply which has evolved gradually from the early days of centralized engine-driven equipment. The original installation comprised three engine-driven d-c. generators totaling 1,600 kw. and feeding out radially over a comparatively restricted area. As the d-c. load increased with plant growth more units and more distribution copper were added until the total engine-driven d-c. capacity at the power house was increased to 6,900 kw. including a 1,500-kw. gas-engine unit. With further expansion the load demand became so heavy that some decentralization of d-c. power supply was almost a necessity. Subsequent additions have been in the form of conversion units located at various points throughout the plant as shown in Fig. 1. The first three substations at first were manually operated because automatic switching equipment was not available at that time. They were automatized subsequently to secure improved operation and still better economy.

Fig. 2. A new 1,500-kw. automatic motor-generator set in the Edgar Thomson works

Fig. 3. D-C control panel for motor-generator set of Fig. 2

The present arrangement was completed with the installation of three new 1,500-kw. automatic motor-generator units similar to that shown in Fig. 2. One each of these units was placed at substations Nos. 4 and 5 and the power house. At the same time a similar manually-operated conversion unit in the power house was automatized. This permitted the retirement of all engine-driven d-c. equipment from active service, although the gas-engine unit and three steam-driven units were retained in place as standby capacity. The result is a complete automatic system of d-c. power supply consisting of 11,000 kw. of distributed automatic conversion equipment, all interconnected through the main distribution system.

The transfer of load from the centralized engine-driven units at the power house to conversion units near the load centers has greatly reduced the average d-c. feeding distance. The predicted saving in distribution losses has been realized in service. Furthermore, primary power now is generated in a relatively large and efficient turbine unit instead of in the small-capacity low-speed reciprocating units. Fig. 4 presents a contrast which illustrates the progress which has been made in the utilization of space and materials. One of the two 1,500-kw. motor-generator sets may be seen between the gas engine unit of the same rating and the

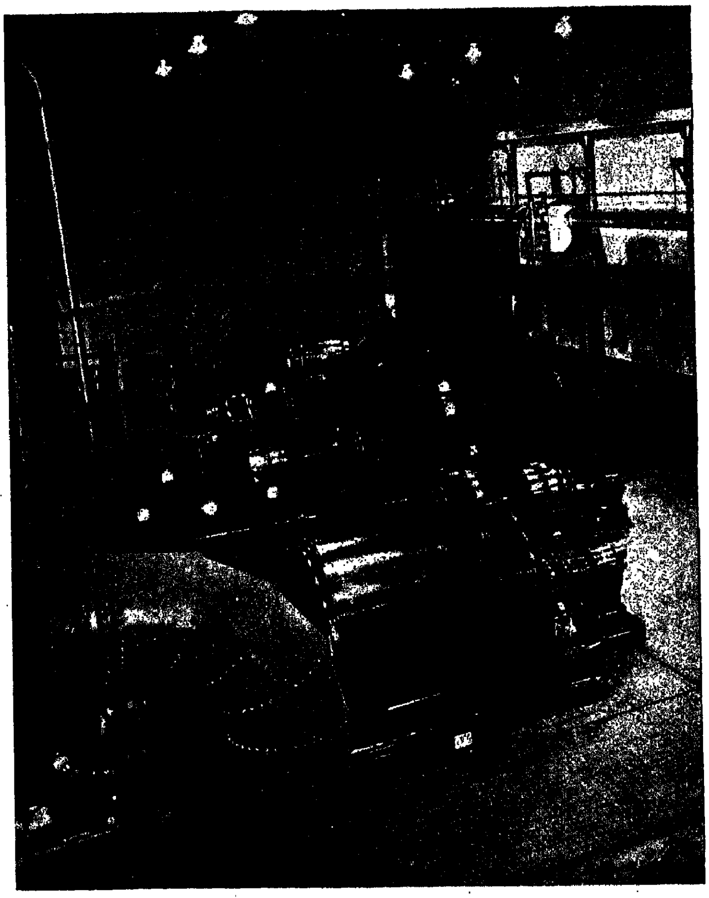


Fig. 4. A contrast in efficiency of space utilization between the old and the new

new 15,000-kva. turbine-generator. The picture was taken from the upper deck of the 1,500-kw. vertical cross-compound steam engine, giving some conception of its physical size.

It should be pointed out that the arrangement of this system necessarily differs to a certain extent from that which might be proposed for a similar, but entirely new installation. For that reason it probably is of greater value as a practical example because the problem ordinarily will arise in connection with the extension or rehabilitation of an existing plant. In any case it is important to realize that joint consideration of load and production requirements, d-c. distribution, substations, and a-c. power supply, is essential to a proper analysis and economical solution. It is only by such a study of the whole system of an industrial establishment that the major component parts can correctly be coordinated and proportioned.

Some Factors Affecting Stability

With the tremendous growth of power-transmission systems has come a corresponding increase in the seriousness of the stability problem. Regulation of generator excitation so that it will follow rapid changes in load constitutes a major part in the solution of this involved problem. Data show that the characteristics of all synchronous apparatus connected to a system must be considered.

By W. A. Merriam and H. R. Arnold**

Senior Students in Electrical Engineering (1929)
University of Colorado, Boulder

POWER limits of transmission systems present a problem which during the last few years has assumed a most important place in the electrical engineering field. When generators became larger, lines longer, and synchronous motors came into general use, it became apparent that some factor other than the temperature rise was beginning to limit the amount of power which could be handled. This factor has become known as the stability limit, and depends not only upon the design of the transmission line itself but also upon the characteristics of its associated synchronous generators and motors.

In the generation, transmission, and utilization of large blocks of power, the stability limit of a system is usually reached before the temperature of the apparatus has reached its maximum safe operating value.

As an example, reference is made to a report on the stability limits of the 220-kv., long distance transmission system of the Southern California Edison Company. This report disclosed that:

1. Adding a new plant and a second unit to the generating capacity at Big Creek would result in a hazard to the continuity of service because the stability limit of the system would then fall below the rated capacity of the combined power plants.
2. When the total system load became approximately 400,000 kw. or more, the condenser capacity then installed would not be sufficient to permit the 375,000 kw. rated output of Big Creek to be transmitted, without calling on the steam plants for wattless energy.
3. While the rated capacity of the Big Creek plant was 375,000 kw., its maximum stability limit with one line in operation was only 294,000 kw. and with two lines in operation, 370,000 kw.
4. The stability limit of that system could be improved by increasing the transmission lines up to a certain number. Should that number of lines be exceeded, however, the system stability would again be lowered.

CHARACTERISTICS OF SYNCHRONOUS MACHINES

In general the characteristics of synchronous machines are fairly well understood and do not need to be treated here in any great detail. However, for the purpose of bringing out those characteristics which bear directly upon the question of stability, a few of the important features will be outlined.

For a synchronous generator it may be said that:

1. The phase angle by which the terminal voltage lags the generated voltage varies with the magnitude and power factor of the load and also with the synchronous reactance of the machine.
2. That part of synchronous reactance which is due to armature reaction varies also with the magnitude and power factor of the load current; and with respect to the main field, may be either cross-magnetizing, bucking, or boosting, depending upon whether the load current is in phase, lagging, or leading with respect to the generated voltage.
3. In order to maintain a constant terminal voltage, the field current must be increased with lagging power-factor loads, and decreased with leading power-factor loads.
4. Decreasing the field current causes the generator to operate on the lower, unstable part of its magnetization curve, thereby decreasing the power limit above which it will drop out of synchronism.

From the foregoing statements it is obvious that any load on a generator which tends to raise the power factor or cause a leading current to be drawn decreases the stability limit of the machine since it reduces the load at which a synchronous motor connected to the generator in question will fall out of step with it. It also very materially decreases the synchronizing power and

---

From "Some Factors Affecting the Power Limits of a Transmission System," National Prize Branch Paper, presented at a joint meeting of the Denver Section and the University of Colorado Branch, A. I. E. E., April 26, 1929.

*Now Assoc. A. I. E. E.

tends to cause the generator to fall out of step with other generators during line disturbances. If the field excitation of the generator could be quickly raised above normal during the time of a disturbance, the machine would be more stable and the liability of its losing synchronism would be greatly reduced.

A similar tabulation outlining those features of synchronous motors which bear directly upon stability limits is as follows:

1. Power factor depends upon both the field excitation and the load on the motor.
2. If the excitation is decreased below normal, the induced voltage or counter e. m. f. is less than the applied voltage, and the motor will draw a lagging current.
3. If the excitation is increased above normal, the induced voltage is greater than the applied voltage and the motor will draw a leading current.
4. Increase in load increases the angle between the applied voltage and the induced voltage. When these two are equal, the phase displacement at which breakdown occurs is 60 deg.
5. The breakdown or pull-out-angle, however, can be increased above 60 deg. by increasing the motor field current. Therefore, an overexcited synchronous motor is more stable than an underexcited one.
6. If the field current is kept constant, the maximum torque that the motor can exert will vary directly with the applied voltage.
7. If the field current is varied with the applied voltage, then the maximum torque that the motor can exert will vary as the square of the applied voltage.
8. Increasing the field current for any given load decreases the angular displacement between the induced and applied voltages. Also, with small field currents, this displacement increases the load rapidly; with large field currents more slowly.

THE TRANSMISSION LINE

Since an ordinary transmission line possesses both resistance and inductance, it would appear to have characteristics similar to those of a synchronous machine. The synchronous machine, however, has armature reaction which the transmission line does not possess; and the transmission line has distributed capacity which the synchronous machine does not have.

So far the discussion has shown that a load on the synchronous motor causes the rotor to lag behind the rotating magnetic field. This is the same as the load causing an angular displacement between the applied and induced voltages of the motor. We have seen also that a load on a synchronous generator causes an angular displacement between its total induced electromotive force and its terminal voltage.

In the same manner, the load on a transmission line will produce an angular displacement between the generated and receiving voltages. Should the load be increased to the limiting value of this angle, instability will result just as in the synchronous motor, and the apparatus at the load end of the line will pull out of step with the synchronous machinery at the sending end.

The vector diagram for a short transmission line carrying a lagging power factor load is shown in Fig. 1. The capacity of the line has been neglected. In this diagran, I is the load current per phase, R is the line resistance per phase, and X, the inductive reactance per phase; V_r and V_g are the voltages at the receiving and generating ends of the line, respectively. It may be seen that the generator voltage V_g is equal to the voltage at the receiver, V_r, plus the impedance drop through the line. The power-factor angle at the load is θ_r and the power-factor angle at the generator is θ_g.

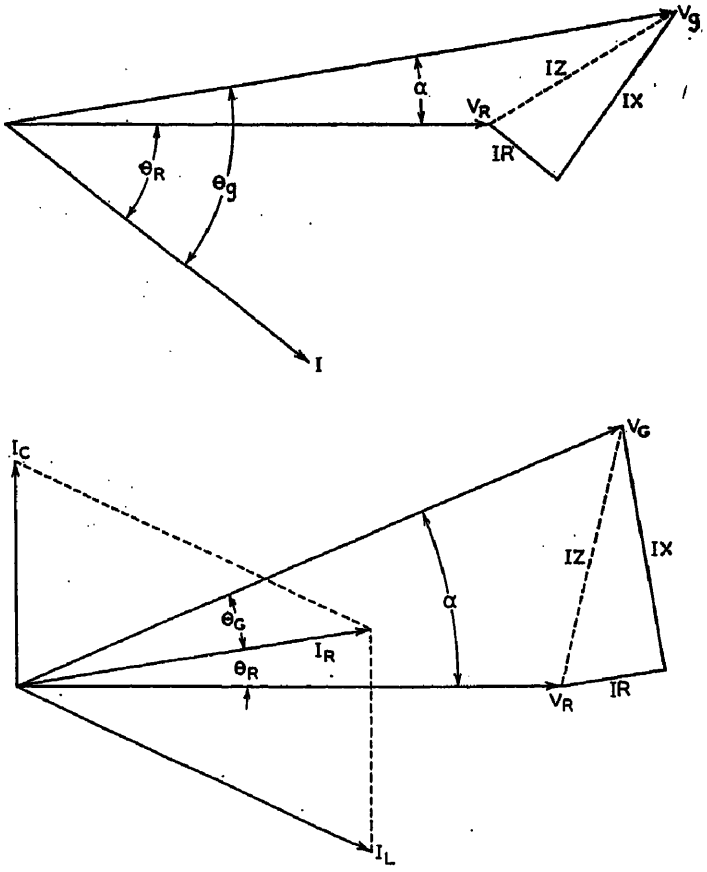


Fig. 1. Vector diagrams for a short transmission line (above) carrying a lagging power factor load; (below) a condenser load is added

Another important thing to note in this diagram is the angle α between the generator voltage V_g and the voltage at the load V_r. It can be shown that when the tangent of α is equal to X/R, α is nearly equal to 90 deg., and the line is then delivering its maximum power. In other words, when α approaches 90 deg., the line becomes unstable. (In actual practise, the limiting angle is somewhat less than 90 deg.)

Now suppose that a condenser is placed at the end of the line so as to raise the power factor; the vector diagram for this condition is shown also in Fig. 1:

The resultant current is now leading the receiver voltage but lagging the generated voltage V_g. The power factor at the generator has been raised, but at the same time the angle α has become larger than before, with the result that the limit of stability will be

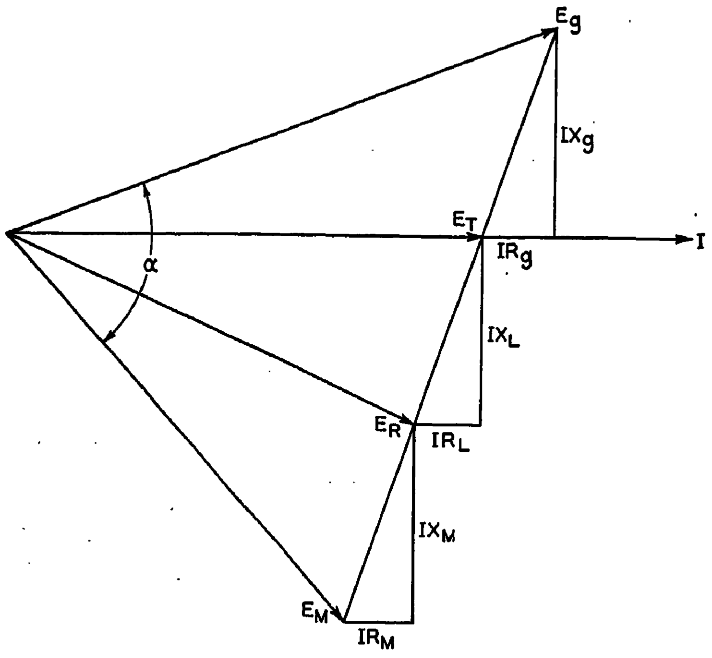


Fig. 2. Vector diagram for a synchronous motor connected through a reactive line to a synchronous generator

reached with a smaller value of current. In other words, the maximum power which the line can transmit has been reduced by adding the condenser load. Notice also that as the leading current in the line is increased, the receiver voltage may become larger than the generator voltage.

From the foregoing discussion and the diagrams in Fig. 1, it is obvious that the power limit of a transmission line can be increased by (1) decreasing the line impedance, (2) using generators and transformers of low impedance, or (3) using generators equipped with quick-acting relays which will cause the generator excitation to vary with the load.

Assume now that a synchronous generator and a synchronous motor are connected together through a transmission line having a certain amount of reactance; the vector diagram for these conditions will appear as shown in Fig. 2. Where, E_g is the total induced electromotive force of the generator, E_t is the terminal voltage of the alternator which is also the sending voltage of the transmission line, E_r is the receiver voltage of the transmission line which is also the terminal voltage of the motor, and E_m is the counter electromotive force of the motor.

When the angle α approaches 90 deg., breakdown occurs; but this breakdown takes place at a lower value of load and current than was the case with the motor connected directly to the generator terminals. With transformers added to the line, still greater reactance would be introduced into the circuit, and under these conditions the angle α approaches the stability limit more quickly with less load.

An oscillogram showing the voltage and current relations in a synchronous motor as instability occurred is shown in Fig. 3. The armature current of the motor may be seen to rise with load and then become unstable as breakdown takes place and the rotor drops out of step. The motor terminal voltage also may be seen to drop abruptly as the pull-out occurs. The field current is interesting because as the rotor slows down it has superimposed upon it an alternating voltage of increasing frequency.

It is now quite clear that an understanding of the problem of system power limits includes a detailed study of the characteristics of every piece of electrical apparatus involved, as well as the transmission line itself.

Another very important point to mention is the fact that raising the power factor may decrease the stability of the system, and that the power limit of a system may actually be greater for low power factor than for a higher power factor. Distributed capacity in the line may also lower the power limit, since it raises the power factor at the generator, thus reducing the field current necessary to produce rated voltage, at the same time decreasing the stability of the machine. This serves to emphasize again the important part which generator excitation plays in stability limits.

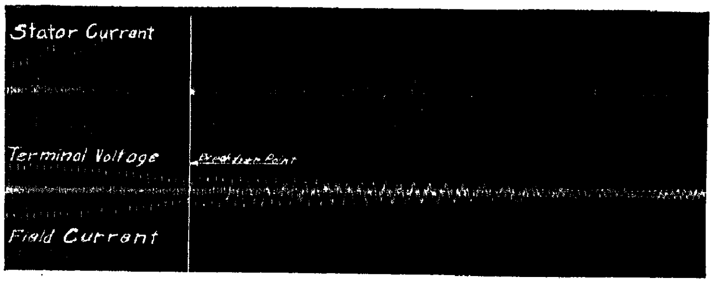


Fig. 3. Voltage and current relations in a synchronous motor at time of breakdown

STABILITY TESTS MADE

The effect of the generator and an inductive line upon the pull-out load of a synchronous motor is shown in Fig. 4. Data for these curves were the results of a test conducted as follows:

First a 25-hp. synchronous motor was connected to a bus of high capacity; the pull-out load and angular displacement was then noted. This pull-out load was 64 kw., and the angular displacement at the motor was 66 deg.

Then the motor was connected to the terminals of a

15 kva. generator and again the pull-out load was noted. This second pull-out load was found to be 32 kw., or one-half the first value, the displacement angle being only 39 deg.

In the third test the motor was connected to the generator through a reactive line. This time the pull-out load was only 18 kw. and the displacement angle 30 deg.

It may be seen at once that the introduction of the generator into the circuit had a much greater effect in reducing the pull-out load of the motor than did the transmission line. It is for this reason that most of the efforts to stabilize power systems are concentrated upon the generator.

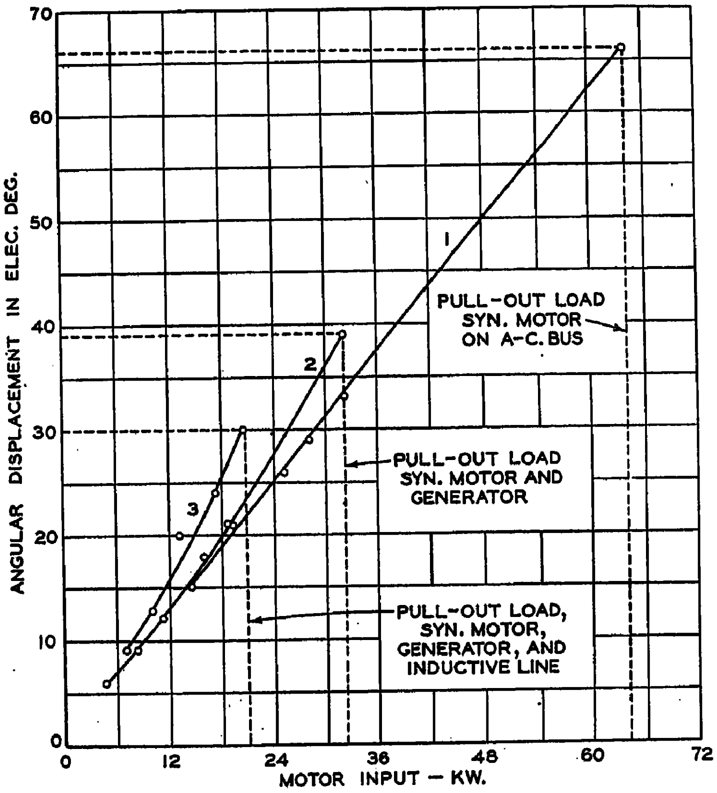


Fig. 4. Pull-out loads for a synchronous motor connected in various ways

Means for Improving Stability

Several means for improving the stability of power systems in order to raise the power limits have been proposed or investigated. Some of these are enumerated as follows:

1. Vary the excitation of generators with the load.
2. Load the bus at the generating station with reactors to lower the power factor on the generators without lowering the power factor of the transmission lines. This would also allow for increased generator excitation, resulting in an increased system power limit.
3. Partially replace synchronous apparatus with induction generators and motors.
4. Lengthen air-gap of generators to increase degree of magnetic saturation.
5. Intermediate condenser stations may be placed at points along the line.

There is no doubt that the most important factor lies in providing generator excitation to follow rapidly any change in load. A new method of increasing the field current as the load increases has been investigated at the electrical laboratories of the University of Colorado with marked success. When the apparatus was devised it was first thought that the idea was entirely new; it was soon learned however, that a similar idea was being developed by the General Electric Company.

The new device acts to greatly increase the generator excitation as the load increases, regardless of what the voltage or power factor might be. A diagram of the apparatus is shown in Fig. 5. Here a generator is connected to a synchronous motor through a reactive line. In the line near the generator terminals are placed three current transformers with their secondary windings, Y-connected to the terminals of a small three-phase induction motor. When a load is thrown on the synchronous motor, the currents in the windings of the current transformers increase, thereby causing the rotor of the induction motor to produce torque in a counterclockwise direction. This lowers a contact into a water rheostat, decreasing its resistance and thereby increasing the field of the generator which enables the system to remain in synchronism. The device is extremely simple, and its efficiency has been demonstrated many times under all kinds of circumstances. A similar device to regulate the slip of large induction motors already is in use.

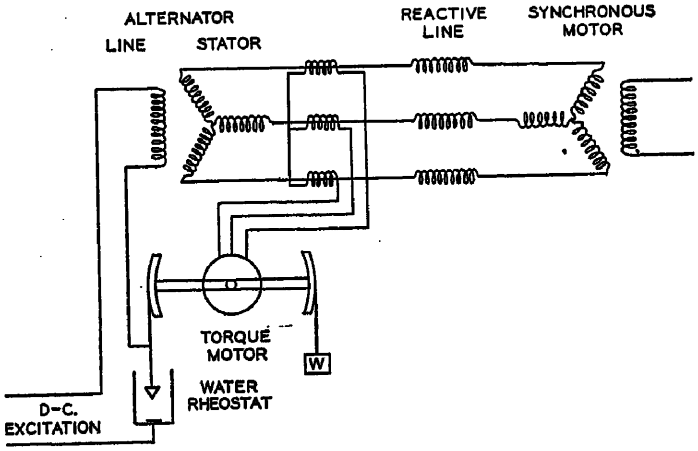


Fig. 5. Arrangement for enabling generator field current to follow rapid changes in load

Several tests have been made by over-exciting a synchronous motor; then loading it to the breakdown point. As already pointed out, the breakdown point under this condition is low, with no regulator of this kind in the circuit. With a leading power factor of 95 per cent, the breakdown point was found to be 22 kw., and the angular displacement 21 deg. Then the same test was repeated with the new excitation regulator. This caused the generator field current to be raised from 2.5 to 8.5 amperes as the load increased, and the breakdown point was raised to 25.5 kw. at an angle of 24 deg.

Another example might be interesting. By means of the over-excited synchronous motor the alternator was was loaded to capacity, whereupon an induction motor of the same rating as the alternator was thrown directly on the line; of course the system pulled out of step. This was repeated with the excitation regulator in the circuit, with the result that the system remained in step and the synchronous motor continued to carry its load as though nothing had happened.

Any scheme of generator field regulation which will, allow the excitation to follow rapidly any changes in the load as this system does should go a long way toward solving the stability problem.

The system just described has the added advantage of remaining operative even under badly unbalanced load conditions.

BIBLIOGRAPHY

1. POWER LIMITS OF SOUTHERN CALIFORNIA EDISON SYSTEM, by W. C. DuVall and Mabel Macferran.

2. SYSTEM STABILITY AS A DESIGN PROBLEM, by R. H. Park and E. H. Banker, A. I. E. E. TRANS., Jan. 1929, p. 170.

3. EXCITATION SYSTEMS, by R. E. Doherty, A. I. E. E. TRANS., July 1928, p. 944.

4. FUNDAMENTAL CONSIDERATIONS OF POWER LIMITS, by R. E. Doherty and H. H. Dewey, A. I. E. E. TRANS., 1925, p. 972.

5. AN INVESTIGATION OF TRANSMISSION SYSTEM POWER LIMITS, by C. A. Nickle and F. L. Lawton, A. I. E. E. TRANS., 1926, p. 1.

6. STABILITY CHARACTERISTICS OF ALTERNATORS, by O. E. Shirley, A. I. E. E. TRANS., 1926, p. 1108.

7. STATIC STABILITY LIMITS AND THE INTERMEDIATE CONDENSER STATION, by C. F. Wagner and R. D. Evans, A. I. E. E. TRANS., Jan. 1928, p. 54.

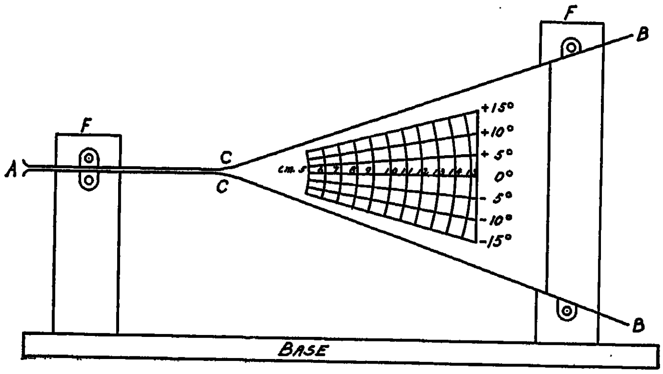
8. STABILITY, by C. A. Powel, *Electric Journal*, June 1929.

Determining the Flexibility of Mica Sheets

WITH the desire to make possible closer grading and duplication of flexible mica sheets, an apparatus called the "fleximeter" has been developed for the New England Mica Company by W. R. Mansfield of that company, and Willis A. Boughton of the Harvard College chemical laboratory

This apparatus (see illustration) is a simple device for measuring empirically the free bending length of a sample strip of the flexible sheet that while in continuous motion downward under pull of gravity, covers a selected arc in a definite time. The following empirical specifications have been selected as giving convenient and rational values:

1. Test strip, 5 cm. wide, 20 to 25 cm. long, and 0.015 in. thick.
2. Horizontal position taken as 0 deg.
3. Arc over which fall is free, + 15 deg. to − 15 deg.
4. Arc over which time of fall is read, 0 deg. to − 10 deg.
5. Time of fall for free end, 10 sec.



Front view of "fleximeter" for mica testing

A test strip is inserted between the pieces *A C* (which are about 6 cm. wide, front to back) is held at the *A* end with the left hand, and stretched against the upper strip *C B* with the right; it is then released at the *B* end and allowed to fall free. The length which will thus fall from zero to the − 10 deg. line in exactly 10 sec., is determined by trial.

This free length of the test strip which requires exactly 10 sec. to fall from zero to − 10 deg., expressed in *millimeters*, is called the fleximeter number and represents the non-resilient flexibility of the sheet.

After the first test on any particular specimen, the strip is turned over and the test repeated. The piece is then turned end for end and another pair of readings taken. Thus four lengths are obtained, the average of which is taken as the fleximeter number. Data illustrating the method and its application to several variety of plates are shown in the accompanying tabulation.

FLEXIMETER NUMBERS OF FOUR FLEXIBLE MICA SHEETS

Sheet No.	Mm. lengths giving 10-sec. fall 1	2	3	4	Avg. length or fleximeter No.
9	58	56	59	54	57
11	67	62	66	65	65
12	77	81	95	86	85
16	114	126	118	120	120

Differences in flexibility such as are indicated between sheets Nos. 9 and 11 could not be distinguished by ordinary inspection and handling; sheet No. 12 was apparently only slightly stiffer than these two, while sheet No. 16 would ordinarily be considered only a grade or two less flexible than the others.

A High-Speed Submarine Cable

Higher transmitting speeds than had been attained previously were made possible in 1928 by the installation of the high-speed loaded cable between Newfoundland and the Azores. Some of the design features and problems involved in duplex operation are described.

By J. W. Milnor and G. A. Randall

Fellow A. I. E. E. Non-Member

Western Union Telegraph Co.
New York

A SUBMARINE telegraph cable of a new type was laid in September 1928, connecting the Western Union Telegraph Company's cable station at Bay Roberts, Newfoundland, and Horta, Azores (See illustrations). This cable combines the facilities for duplex, or two-way operation inherent in non-loaded cable, with the high-speed characteristics of the new, loaded type. Tests on this cable have shown that a duplex speed of at least 1,400 letters per min. (42 cycles per sec.) simultaneously in each direction is now practicable. If operated simplex,—*i. e.*, in one direction only,—the speed is over 2,500 letters per min. It therefore provides the greatest message-carrying capacity of any existing transocean cable.

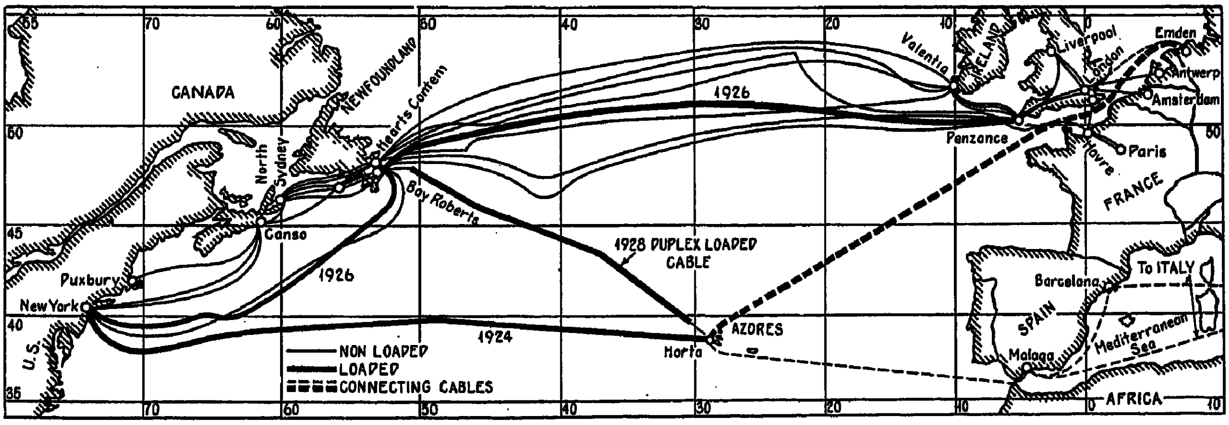


Fig. 1. Western Union cable system in the North Atlantic

The first long continuously-loaded submarine telegraph cable was laid in 1924; since then, eight other loaded cables of similar construction have been laid by various companies. These cables have several times the operating speed of non-loaded cables, but their electrical characteristics are such that they are much more difficult to duplex, and, therefore, have been operated simplex only. There are many situations, however, where duplex operation is decidedly advantageous, consequently it was inevitable that attempts should be made to develop a type of cable capable of high-speed duplex operation.

General Theory of Duplex Cables

In order to duplex a cable, it is necessary to provide at each terminal station a so-called "artificial line," the impedance of which must closely match or "balance" that of the cable throughout a range of frequencies from about half the fundamental signaling frequency up to about 1.6 times that frequency.

A loaded cable is more difficult to balance for three reasons: (1) There are larger irregularities in the impedance measured at different points; (2) the effect of such irregularities upon balance is more pronounced in a loaded cable; and (3) the inductance and effective resistance of loaded cable undergoes continuous, small variations in accordance with the changing magnitude of the signaling current.

Each of these difficulties may be reduced in importance by loading only the central portion, and suitably designing each section. For the non-loaded portion the duplex balance may have about the same high accuracy as has been customary in the past in non-loaded cables. In the part of the artificial line corresponding to the loaded portion, a duplex balance of a much lower degree of accuracy is sufficient.

Some of the various factors affecting accuracy and stability of balance, are: (1) The attenuation from end to end of the cable as measured at working frequencies; (2) the attenuation from end to end of the loaded portion of the cable; (3) the "current coefficient of inductance," *i. e.*, the fractional rate at which the induc-

---

From "The Newfoundland-Azores High-Speed Duplex Cable," (N. 31-12) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

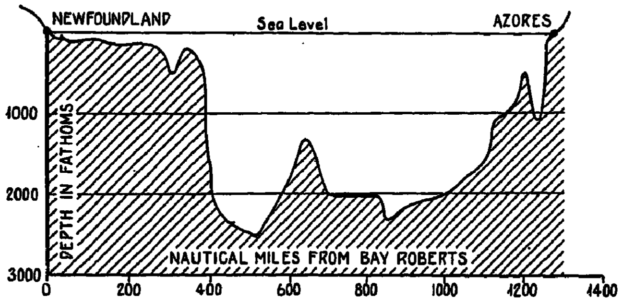


Fig. 2. Profile of ocean bottom route of the 1928 cable

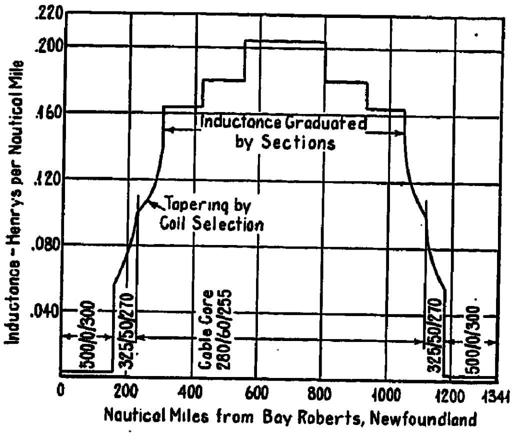


Fig. 3. Inductance of different sections of cable

tance of loaded cable varies with current; and (4) tapered loading.

DESCRIPTION OF 1928 CABLE

The total length of the cable is 1,341.2 nautical miles. Each non-loaded end portion is 160 miles in length; the heavily-loaded central section is 881 miles in length, while intermediate between these two types there are sections of lightly-loaded cable, each 70 miles in length. Further details of the design and electrical characteristics of each section are given in Table I.

TABLE I—CHARACTERISTICS OF CABLE CORE FOR DIFFERENT SECTIONS

Factory values per nautical mile, at 75 deg. fahr.

	Sections		
	Ends	Intermediate	Center
Weight of copper—lb.	508	329	284
Weight of loading—lb.	non-loaded	51	60
Weight of gutta percha—lb.	303	275	258
D-c. resistance—ohms	2.34	3.60	4.18
Capacitance—μf	0.357	0.344	0.342

The loading throughout the central and intermediate portions is Mumetal wire supplied by the Telegraph Construction and Maintenance Company, Ltd., of London. This material is similar to permalloy. A permeability range from 2,000 to 6,800 was obtained in different sections of the cable by controlled variations in the annealing process. The average values of inductance are given in Fig. 3.

In order to reduce extraneous voltages picked up in shallow water it is customary to carry a second and sometimes a third core in the sections near the ends. At Bay Roberts the receiving sea earth is 50.1 nautical miles long and is grounded to the cable sheath through a resistance of 160 ohms. At Horta, Azores, the corresponding length is 2.39 miles and is grounded directly to the sheath.

CABLE TESTS

Various tests were made on the cable both during manufacture and also after it was laid. The total d-c. resistance is 4,521 ohms; the total capacity 463 μf.

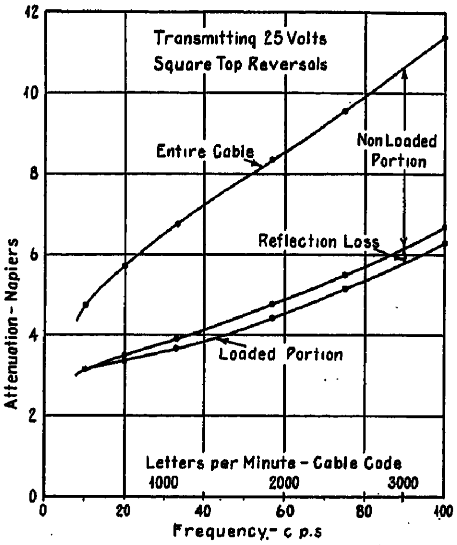


Fig. 4. Attenuation of laid cable

The results of some of the attenuation tests with square-topped transmitting waves are shown in Fig. 4.

The time of propagation of signals over the cable is 0.235 sec. at 60 cycles. It has been estimated that during the process of laying, the mechanical strains placed upon the cable caused an average of about 13 per cent loss in the inductance.

ARTIFICIAL-LINE EQUIPMENT

An essential part of this cable project has been the provision at each cable station of an adequate artificial line for completing the Wheatstone bridge arrangement which is necessary for duplex operation. The present equipment is somewhat more complicated than in the case of the usual artificial line for low-speed cables. In addition to resistance and capacity elements, the present equipment includes means for simulating the inductance of both loaded and non-loaded portions, the eddy-current losses in the loading, sea-return losses, and dielectric losses. A compensating arrangement is introduced to prevent "filter oscillations" between the condenser and inductance units.

As in the case of the cable itself, the change of inductance with current in the coils of the artificial line was given consideration and was held to a relatively small amount. It was also necessary to exercise unusual precautions to guard against the effects of temperature changes and of pick-up of extraneous disturbances by the coils.

It has been estimated that for transmission of telegraph characters, the impedance of the artificial line matches that of the cable to an accuracy of roughly one part in 4,000, and for sine waves in the range between 35 and 55 cycles, better than one part in 7,000.

Merits of Simplex and Duplex Cables

In determining the kind of cable facilities best suited for handling telegraph traffic between two given areas, there are many factors which must be considered; among these are the length of the circuit, the desired message capacity, the relative amounts of urgent and deferred traffic, the difference between the loads in each direction, the difference in time between the terminal areas, the nature of existing cable facilities, and the handling of traffic in case of failure of one or more cables.

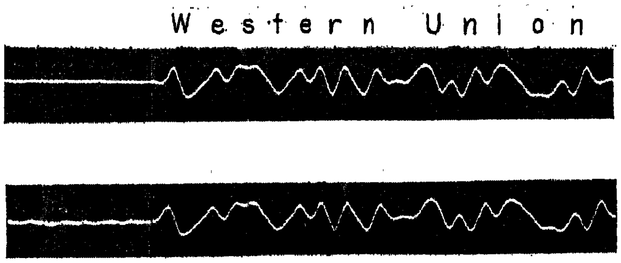


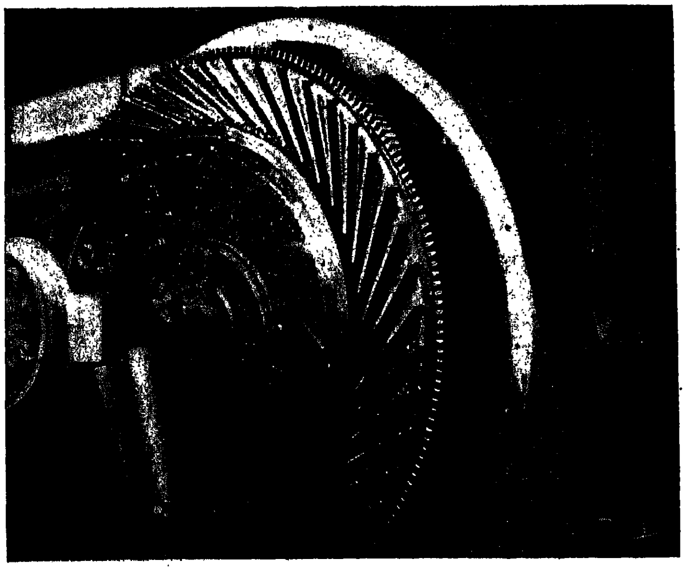
Fig. 5. Cable-code signals as received at Bay Roberts showing in the upper record simplex westward transmission, and in the lower record duplex eastward and westward transmission

Where the load is sufficient to justify only a single cable, and the difference in time between the terminals is not excessive, the duplex type usually offers the most convenient solution. If the terminals are so located that there is a considerable time difference, the simplex cable has the advantage. Where the amount of traffic is enough to justify two or more cables, there are various possible solutions; in some cases it is probable that a combination of simplex and duplex cables is the best solution. It also appears probable that neither the simplex nor the duplex cable has as yet reached its limit of economical development; hence, it is hardly practicable at this time to give a final answer to these questions.

Metal-Clad Synchronous Motors Latest Thing for Nitrate Plants

Working in an atmosphere of fine nitrate dust, the 250-hp. Westinghouse synchronous motor shown under construction in the accompanying illustration, obviates the usual danger of nitric-acid damage to its windings. Built to fit their job, the vulnerable parts of these motors are metal-clad and in addition are supplied with a slight static pressure inside to prevent the harmful dust from leaking in. Inclined fins on the metal enclosure not only throw off heat, but guide along the most efficient route the cooling air supplied by the fan on the rotor. Without these odd-looking fins the operating temperature of the motor would be much higher. These motors are designed to operate on 550-volt, 60-cycle circuits and have a synchronous speed of 450 r. p. m.

Although built to meet many requirements which do not handicap the usual open synchronous motor, these motors are only about one-fifth larger than the ordinary type. Besides being protected from nitrate dust, they produce 120 per cent starting torque and 100 per cent pull-in torque—about twice the usual values. Rated at 90 per cent leading power factor these motors will carry full mechanical load while also furnishing power-factor correction. And although they work a mile above sea level in rarefied atmosphere, the temperature rise is but slightly more than usual, being rated at 55 deg. cent. for El. 5,000 ft.



One of the 250-hp. synchronous nitrate-crusher motors built for the Anglo Chilean Corporation. Note the metal enclosures protecting the windings; cooling fins serve also as guide vanes for circulating air

Noise—

With America becoming "noise conscious," electrical engineers are finding it necessary to devote increasing attention to the reduction of noises caused by electrical machinery. Progress in this direction, both in specially designed instruments and in mitigative measures adopted, is indicated in the accompanying articles.

NOISE is a comprehensive term which includes almost all sounds except music and speech, and covers the entire audible range both in loudness and frequency. Noises set up by electrical machinery are caused chiefly by vibration of the machines as a whole or in parts, and are usually recurrent and approximately steady as contrasted with the random character of ordinary street noises. The resultant noise perceived by the ear, however, is in the main a mixture of two components, one emanating directly from the machines and the other radiated from the floor and walls of surrounding enclosures.

In order to control noise a thorough understanding not only of the causes but also of the mode of transmission of noise is necessary. It is in this aspect of the problem that accurate measurements are especially helpful and with instruments now available information may be obtained which will serve as a basis for changes in machine design. There is a tendency, however, to reduce the size and weight of machines due to the improved electrical and magnetic materials now available. This complicates still further the already difficult problem of designing quiet machinery, since the lighter structures are more susceptible to vibration.

Difficulties in Measuring Machine Noise

By
B. F. Bailey
Fellow A. I. E. E.
University of Michigan
Ann Arbor, Mich.

WHEN a new and useful machine is first introduced, nobody thinks much about possible refinements. Thus when electric motors were first used, reliability was the essential quality. Soon afterward price became of importance; still later, efficiency was considered. At the present time attention is being turned to noise and the point has now been reached where the need of adequate means for noise measurement is felt. At present the intensity of a noise is stated about as accurately as the Irishman's reply that a certain object was "about as large as a lump of coal."

Two distinct types of measuring devices are needed: One, if possible, to give an indication of the intensity of a sound with a single reading in the same manner in which an ammeter gives at once the current in a circuit; the other, to make possible the analysis of a sound into its component parts in much the same manner that the components of a current can be analyzed by means of the oscillograph. The first type will be useful to the manufacturers and users of machinery in determining quickly and easily whether a machine comes within certain prescribed limits of quietness. The second type will be useful to the machine designer by enabling him to determine and eliminate the sources of noise.

DIFFICULTIES OF THE PROBLEM

When an attempt is made to develop an instrument which will give an objective indication of the degree of noise from a given source, serious difficulties are encountered. Unfortunately the effect upon the human ear is not directly proportional to the physical intensity of the sound. A sound of very high pitch, for example, cannot be heard at all; and the same is true of sounds of very low pitch. Moreover the range over which the ear can hear varies with different persons and at different times. The problem is further complicated by the fact that what is really desired is to find out how disagreeable a certain noise is regardless of its intensity.

Another difficulty arises from the fact that in an ordinary room not only is the sound itself heard but also many reflections of that sound. A sound indoors at a certain distance may easily produce ten times the effect of the same sound at the same distance in open air. Moreover in any ordinary room the sound will be focused at certain points and consequently will be much louder there than at other parts of the room, and sometimes even louder than at the object emitting the sound. One obvious remedy is to make all tests in sound-proof rooms. But while this is possible in the laboratory, serious difficulties would be encountered in applying the method to routine production. A method

---

From "Measurement of Noise in Electrical Machinery," (No. 31-68).

a factor in
Machine Design *and* Operation

THE articles on these and the following twelve pages comprise abstracts of a noise abatement symposium presented at the A. I. E. E. Rochester, (N. Y.) District meeting. These consist of (1) a general review of the difficulties involved in obtaining suitable noise measurements, by B. F. Bailey, University of Michigan; (2) a description of a new sound meter which simulates the response of the human ear, by T. G. Castner, Bell Telephone Laboratories, E. Dietze and R. S. Tucker, American Telephone and Telegraph Company, and G. T. Stanton, Electrical Research Products Inc.; (3) a résumé of the measurement of machinery noise featuring a new audio noise meter, by H. B. Marvin, General Electric Company; (4) a study of the noises in induction regulators, by J. P. Foltz and W. F. Shirk, Westinghouse Electric & Manufacturing Company; (5) a discussion of magnetic noises in synchronous machines, by Quentin Graham, Sterling Beckwith, and Frank H. Milliken, Westinghouse Electric & Manufacturing Company; (6) some interesting results obtained with elastic supports, by E. H. Hull, and W. C. Stewart, General Electric Company; (7) an outline of present means of reducing substation noises, by E. A. Bishop, Commonwealth Edison Company.

used with some success is to provide a very large rotating vane to break up reflections and prevent them from concentrating at any one point.

As previously indicated there is need also for some means by which sound can be analyzed into its various components and the intensity of each of these determined. One method now in use consists in using a microphone to pick up the sounds which in turn are amplified by vacuum tubes and then passed through a variable filter. Since only one component passes through the filter at a time, it can thus be measured by a galvanometer or similar indicating device, a method, which while obviously slow, gives complete information in regard to the sound produced and is unquestionably of great value to the designer.

ORGANIZATIONS INTERESTED

Several manufacturers of various types of machinery have become greatly interested in methods for measuring accurately and quickly the noises produced by their products. In the past five years approximately $250,000 has been spent upon such projects at the University of Michigan alone; methods have been devised for measuring the noise produced in ball and roller bearings, gears, electric carpet sweepers, and other devices; instruments have been constructed and are now being used in routine production in several factories.

Certain national societies, among them the National Electrical Manufacturers Association and the American Society of Mechanical Engineers, have become interested in the problem and have appointed committees to consider the subject. The committee of the former organization was instructed first to find or devise a method of measuring the noise produced by electrical machinery; then, when such a device has been found, to formulate standards of allowable noise for this machinery. Some of the difficulties in the first part of this problem have already been indicated. Considering even the enormous variation in horsepower, speed, frequency, and number of phases, of electric motors alone, it will be apparent that the difficulties of the second part of the assignment are no less than those of the first part.

CONCLUSIONS

It is evident that the American people as well as the manufacturers of electrical machinery are becoming "noise conscious." Great progress has been made within the past few years in devising means for measuring noise as well as improving machinery so that it will be less noisy. Although the difficulties of the problem are great, there is reason to hope that in the near future some device will be perfected to give an immediate indication of the effect of any given noise upon the human ear. After all, what is desired is to eliminate noise. But with such an instrument available progress will be much more rapid for a definite measure of noise will then have been achieved in place of the present imperfect estimate based entirely upon personal judgment.

A New Meter for Noise Analysis

By
T. G. Castner Non-member — Bell Telephone Laboratories, Inc., New York
E. Dietze Non-member — American Telephone & Telegraph Company, New York
G. T. Stanton Associate A. I. E. E. — Electrical Research Products, Inc., New York
R. S. Tucker Associate A. I. E. E. — American Telephone & Telegraph Company, New York

A SOUND METER has recently been developed in the Bell System, which measures acoustic noises and sounds in general. The aim has been to have its indications accord with present information on the response of the ear as far as practicable in a simple portable device. The response of the meter to sound impulses, in general an important part of noise, has been carefully considered. There is also under development an attachment to analyze sound both on a single-frequency and band-frequency basis.

The meter consists of a sound-pick-up device to convert acoustic into electrical energy, a multi-stage vacuum-tube amplifier, a calibrated gain control to measure sound levels over a range of 90 db. (corresponding to a range of 1,000,000,000:1 in input powers), an electrical network to weight different frequencies in a manner similar to that in which they are weighted by the ear, a rectifier and visual indicating meter which responds in a manner similar to the ear, and means for over-all acoustic calibration.

Calibration is in terms of physical units rather than in some other terms which might depend upon the "personal equation." The sound meter is calibrated in terms of a 1,000-cycle pressure of 0.001 dyne per sq. cm. in a free progressive wave which pressure is called the "reference sound level." Sound levels measured are expressed in decibels above this reference point. For a 1,000-cycle tone, this reference level is somewhat above the minimum threshold of audibility of the average observer.

NOISE AND HEARING

In the design of a meter of this type, certain physical characteristics of noise and hearing must be considered in order that its indications will be correlatable with noise effects. These effects are known to vary with time in many different ways but the important part played by the sharply peaked wave forms of some noises generally is not fully realized.

Principal characteristics of hearing taken into account in the design of the meter are those relating the sensation of loudness to the physical properties of a sound, such as intensity (sound power passing through unit area), frequency, duration, and complexity of wave shape. This subject is not discussed here as a great deal has already been published regarding it.

DESCRIPTION OF SOUND METER

Usefulness of a device for general noise measurements depends largely upon portability, as in most cases the meter must be taken to the location of the noise. For this reason, therefore, the sound meter has been made small and light. Fig. 1 shows a schematic layout diagram while in Fig. 2 is shown an experimental model of the meter. Batteries are contained in a separate box but both units together can be carried easily by one man.

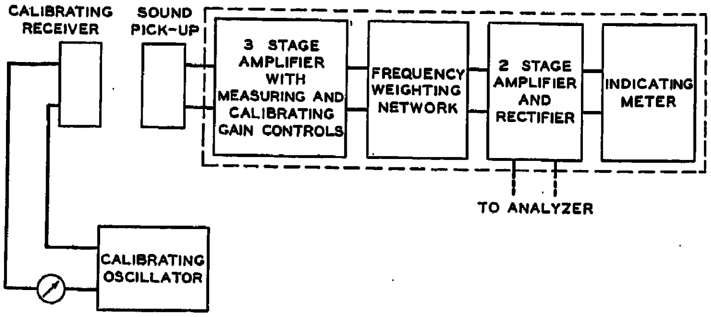

CALIBRATING RECEIVER
SOUND PICK-UP
3 STAGE AMPLIFIER WITH MEASURING AND CALIBRATING GAIN CONTROLS
FREQUENCY WEIGHTING NETWORK
2 STAGE AMPLIFIER AND RECTIFIER
INDICATING METER
TO ANALYZER
CALIBRATING OSCILLATOR

Fig. 1. ***Layout of noise meter showing arrangement of component parts and calibrating apparatus***

The meter is capable of measuring noise magnitudes from about 10 to 100 db. above reference sound level, and covers a frequency range from about 50 to 10,000 cycles per sec. It is direct reading in db. above reference sound level, and weights noise components at different frequencies approximately according to the 40 db. curve of Fig. 3. An adjustable frequency-weighting is not thought necessary since it would not appreciably change the results of more than a small proportion of the measurements.

A full indication on the meter is obtained in about 0.2 second. The fact that a 0.2-sec. response approximately simulates that of the ear can be demonstrated by watching the movements of the needle of a meter having this response and at the same time listening to the variation of the noise. In such a test the visual and aural impressions are approximately synchronized. Measurements of certain noise impulses taken with this meter and with a meter requiring about 5 sec. to reach full indication gave differences in the readings on the same impulses amounting to about 15 to 30 db.

The output circuit of the sound meter follows approximately a "square law;" that is, the meter reading is about the same for a sinusoidal voltage as for a steady

---

From "Indicating Meter for Measurement and Analysis of Noise," (No. 31-80) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

complex voltage of the same r. m. s. value. Thus the reading is a function merely of the average impressed power and not of wave shape. The reading should preferably not depend upon phase relations, which are affected by phase shift in the meter.

The meter has been designed so that its readings with negligible error for common noises are proportional to the input level over the whole 90 db. range provided. It is practically completely shielded against electrostatic fields. The shielding provided against stray electromagnetic fields is believed to be sufficient for practical purposes.

Calibration

Primary absolute calibration of the sound meter was made by placing the sound pick-up in a 1,000-cycle free progressive wave at a point at which the pressure was determined from Rayleigh disk measurements.

Great care has been taken to make the meter electrically stable. In addition, in order to verify in the field that the meter is reading correctly, a means for making an over-all acoustic calibration has been provided. The apparatus for this secondary calibration consists of a stable telephone receiver, a 2,000-cycle oscillator, and a means for coupling the receiver to the sound pick-up. This calibration may be made in a few seconds.

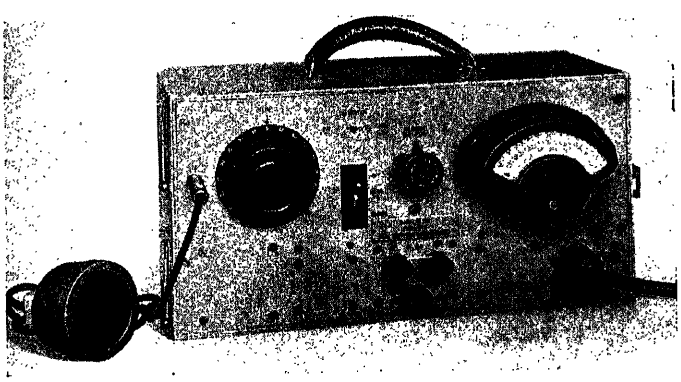


Fig. 2. An experimental model of sound meter with pick-up device at the left

An attachment to the sound meter is now under development, by means of which either a quantitative frequency analysis of a sound or a measurement of the amount of sound energy in various frequency bands can be made easily and quickly.

Uses of Sound Meter

The sound meter is applicable to a great many acoustic problems. It is necessary, however, to take care that sounds other than those under investigation do not affect the measurements, and to take account of the test conditions in the interpretation of the results, *i. e.*, the acoustic properties of the surroundings, the location of the pick-up with respect to the noise sources, and other influencing factors.

This meter can be used to make noise surveys; to aid in ascertaining desired levels of noise in various cases, and determine when these levels have been met; to measure machine noises; to measure noise in residential neighborhoods where power substations may be installed; and to measure sounds other than noise (in recording and broadcasting work, for example, to determine optimum levels and sound distributions).

With the analyzer more detailed information will be obtainable than is furnished by over-all sound measurements alone. This device will aid in determining whether an undesired sound will be covered up by the general noise, or whether a signal will be audible through this noise. Determination of the frequencies of noise components permits selection of the sound-absorbing material most effective in reducing noise. Determination of the noise components of a machine may yield data as to the contribution of each individual noise source in the machine; such data can then be applied in the redesign of machines to reduce noise. The control of uniformity of manufactured products by means of acoustic measurement also offers a potential field of application for the sound meter.

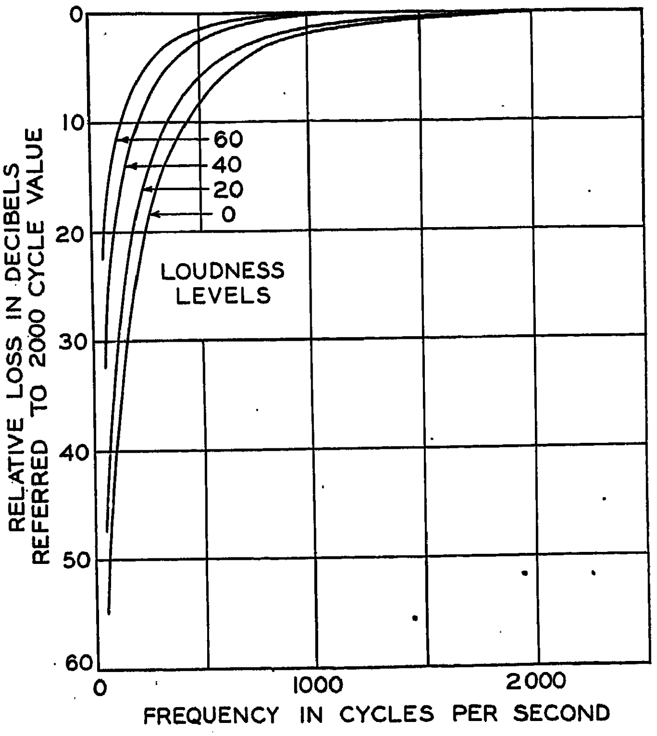


Fig. 3. Frequency weighting curves for equal loudness

By means of a suitable electrical input the sound meter may even be used in certain cases to measure electrical levels or to analyze electrical quantities; but it is believed that this new meter will prove of greatest value in the study of noise and sound problems which are almost daily increasing in variety and complexity.

Magnetic Noise in Synchronous Machines

By
Quentin Graham Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Associate A. I. E. E.
Sterling Beckwith Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Non-member
Frank H. Milliken Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Non-member

MAGNETIC NOISE in synchronous machines, particularly those of the low-speed class, has been a source of annoyance to both designers and operators, but literature on the general subject of noise is notably free from any discussion of the specific causes of noise in this type of machine. In this article an attempt is made to point out some of the causes of this noise and to show the extent to which they may be controlled by the designer.

When the noise problem in synchronous machines was first investigated several years ago there was a great deal of speculation concerning the particular part of the machine that produced the principal vibration. Suspicion pointed to the stator teeth, the overhanging tips of the poles, and the poles as a whole. It finally became evident, however, that one of the principal sources of noise was the vibration of the stator as a unit.

The most frequent cases of stator vibration arise from flux distributions which, because of unequal magnetic pull on all axes, make the stator to assume an elliptical shape. This condition requires, in effect, a two-pole flux distribution superposed on the normal distribution. It will be shown later that there are several ways in which such a flux distribution may be set up. It is also possible to have a four-pole (or more) distribution which will tend to distort the stator at four (or more) points. Since the stator structure is much more rigid with respect to these forces than to the two-pole force, they are not such frequent sources of trouble.

Rotor vibration takes more forms than stator vibration. One possibility is for the rotor rim between arms of the spider to move in and out, either in phase or 180 deg. out of phase, with the segment between the succeeding spider arms. Another possibility is for the poles to vibrate circumferentially. A third mode of vibration occurs when parts of the spider rim vibrate axially. This last type of motion resembles that occurring in gears.

Under certain conditions it is possible to have magnetic forces tending to pull the rotor out of center. This requires a distribution of force having only one wavelength in the circumference of the machine. It might be called by analogy a one-pole distribution and is similar to what occurs when the air-gap is unequal. Such forces are found in induction motors[1] (for numbered references see bibliography) but would occur in synchronous machines only if odd numbers of slots were used. Since the number of slots in synchronous machines is almost invariably an even number, especially in large machines, this type of vibration rarely occurs and will not be discussed here in detail.

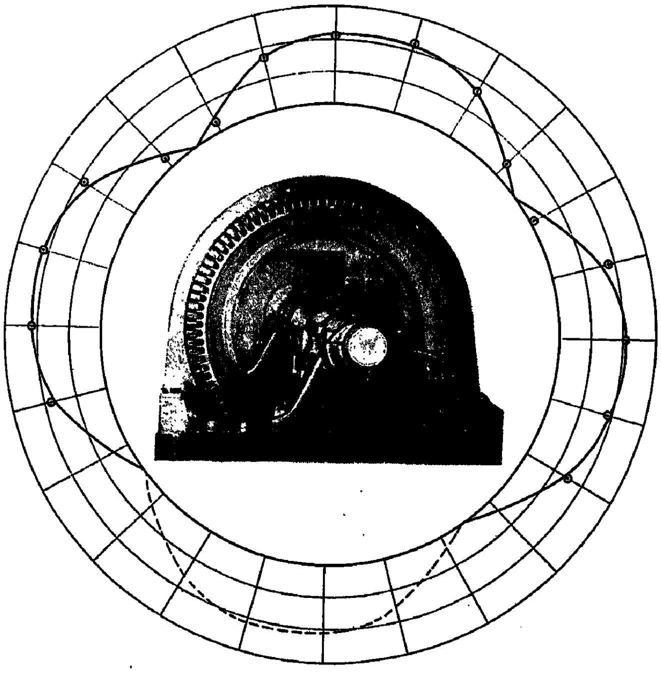


Fig. 1. Pole-frequency vibration around the circumference of the stator. The motor in the center is correctly oriented with respect to the measurements

Two important classes of noise or vibration with reference to frequency have been noted; namely, (1) tooth frequency noise, usually occurring at no-load and independent of armature current, but sometimes proportional to or increasing with it; (2) pole-frequency noise or noise of twice the line frequency which depends upon the armature current and is thus much lower in tone than the other type of noise.

It is realized that noises of other frequencies may exist but as they are relatively unimportant they will not be considered here.

TOOTH-FREQUENCY FORCES

In order to explain the cause of tooth-frequency noise, it is convenient to consider the change in flux of a single pole as it moves over one stator tooth pitch. Clearly there is some point where the flux is at maximum and some point where it is at minimum; thus the flux in each pole rises and falls slightly each time a tooth pitch is traversed, and the magnetic pull between that pole and the stator goes through a corresponding cycle. Assume for example that a machine has 14 poles and $5^{1}/_{7}$ stator slots per pole; it is evident that if Pole No. 1

From "Magnetic Noise in Synchronous Machines," (No. 31-78) presented at the North Eastern District meeting of the A.I.E.E., Rochester, N.Y., April 29-May 2, 1931.

has maximum flux at a given instant, Pole No. 2, 1/7 tooth pitch from the same relative slot position will have slightly less flux. Each succeeding pole will have a little less flux until the minimum is reached, after which there will be a gradual increase. Thus there will be two areas diametrically opposite having high flux density and two areas on an axis at 90 deg. to these, having low density. The result is a higher magnetic pull along one axis and a tendency to give the stator an elliptical shape.

It now remains to see what happens to the magnetic pull or stator distortion as the field member rotates; using the given example, it may be seen readily that when the rotor has moved 1/7 tooth pitch, the point of maximum density has shifted from Pole No. 1 to Pole No. 2. When a tooth pitch has been traversed, the point of high density has moved seven pole pitches as measured on the rotor. With reference to the stator, the distorting force has moved seven pole pitches plus one tooth pitch. Thus it may be seen that a given point on the stator goes through a complete cycle from maximum pull, through minimum pull, and back to maximum, while the rotor moves slightly less than one tooth pitch.

In order to have a gradual distribution of density or pull over a group of adjacent poles, certain fractional numbers of slots must be used. With certain other fractional numbers it is shown that the poles having high density at a given instant are so alternated with poles of low density that the frame deformation is of a different form. The curves of magnetic pull plotted against pole position in these cases have two or more maximum points but due to the greater rigidity of the frame, a pull of short wavelength is usually unimportant. There may be a small component of pull which has a two-pole distribution, but its magnitude is so much less than in the previous case that there is seldom any trouble from noise.

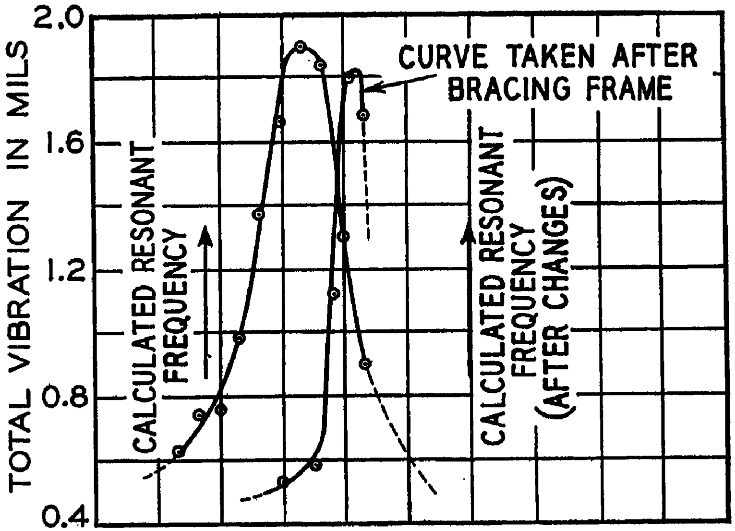


Fig. 2. Resonance curves for pole-frequency stator vibration before and after bracing the motor frame

Pole-Frequency Forces

It has been previously noted[2] that the armature m. m. f. waves of machines having fractional slot windings contain components of low-harmonic order. With certain slot arrangements there may be a component wave of m. m. f. and flux having a two-pole distribution superposed on the main distribution of flux, which will cause elliptical distortion of the stator just as in the case described under no-load noise. In this case the two-pole field travels at the synchronous speed of a two-pole rotor. Similarly, a sub-harmonic having a four-pole (or more) distribution may distort the frame at four (or more) points and cause vibration. In all cases the frequency will be twice that of the supply circuit since the rate at which poles of the superposed distribution pass a given point on the stator is the same regardless of the number of poles.

While it is convenient to start from the assumption of a single two-pole component of armature m. m. f. in describing the effect of a two-pole pull, this simple type does not complete the story. When any two components of flux exist, differing in harmonic order by two, there will be a resulting modulated wave which gives the same effect as a simple two-pole distribution.[3] When the order of magnitudes is examined it is found that these modulated waves are really the important ones since in some cases the several components may combine in such a way as to partly cancel one another, while in other cases they add to form a higher total.

The elimination of any one unwanted harmonic can be accomplished by changing the coil grouping[3] in two relatively simple ways: (1) by cutting out coils the electrical position of which coincides with the vector position of the harmonic to be eliminated; or (2) by shifting coils from one phase group to the next adjacent group in such a way that the troublesome harmonic is

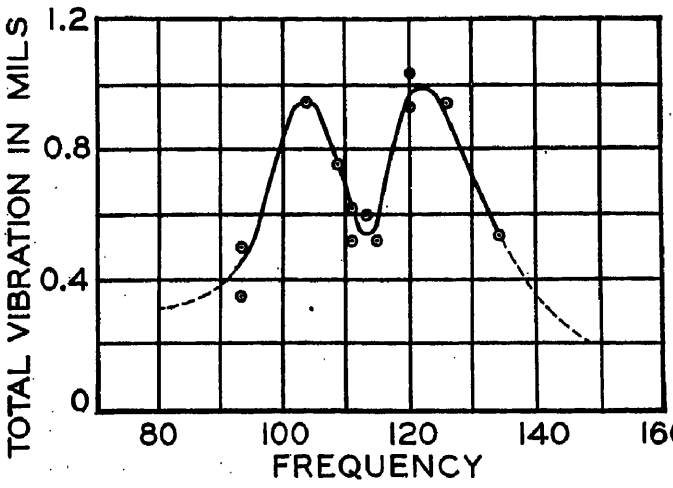


Fig. 3. Resonance for pole-frequency stator vibration showing dip in curv due to an end bell on motor frame

decreased without appreciably reducing the terminal voltage of the machine.

The existence of various forces tending to distort the machine has been established and it has been pointed out that the most serious cases of trouble arise from a two-pole pull which forms a single rotating ellipse since forces distributed in this way produce the greatest deflection. Experience, however, seems to show that nearly all cases of objectionable noise occur when there is resonance between the magnetic forces and some part of the mechanical structure. For this reason even the four-pole (or more) force distribution may result in trouble if the necessary resonant condition exists.

MECHANICAL ASPECTS

It may not be entirely obvious that a rotating deflection of the stator can be affected by resonance; it can be shown, however, that the rotating pull or deflection may be considered as the result of two stationary pulsating pulls which are 90 deg. apart in space and time. Thus resonance to a traveling elliptical deflection is quite possible although in practise one of these components is usually damped to some extent by the frame supports.

Tests made on a number of machines have shown that usually resistance to a distortion in the plane of the laminations is entirely dependent upon the frame or clamping plates and not upon the laminations. The laminations become so much dead weight attached to the frame but add nothing to its stiffness. A formula developed by Timoshenko[4] for simple rings has been applied to complete stators in a number of cases and has given useful results, as shown by the comparison between calculated and test results in Fig. 2.

While it has been shown that stator vibration is of consequence only when there is a force tending toward elliptical distortion of the frame, rotor vibration may be set up also by a periodic variation in the magnitude of the normal radial gap force, such as that occurring in integral slot machines.

Rotor resonance is affected so much by the rotor arms that it is not susceptible to such accurate calculation as the stator. Two formulas,[5] however, one for a section of rim pivoted at both ends and one for a section of rim fixed at both ends, have been found useful in giving the probable upper and lower bounds of resonant frequency for radial vibration.

A formula for the resonant frequency of gears with different modes of rim vibration is also available[6] and has been found useful but requires a great deal of empirical correction when applied to plate spiders.

Tangential vibration of the stator teeth is often throught of as the simplest and most probable form of mechanical vibration causing tooth frequency noise. If it be agreed that resonance is necessary for appreciable tooth motion, then almost all machines are out of the range where tooth resonant frequency approaches tooth frequency. The assumption that resonance is essential is justified by past experience and from a consideration of the stiffness of the teeth appears reasonable.

Results of several vibration tests of machines having pole-frequency vibration are shown in the accompanying illustrations. Measurements were made by amplifying the resistance variations in a phonograph pick-up the needle of which followed the motion of the frame. The accuracy of this method is indicated by the consistency of the test results.

TEST RESULTS

Variation in the amplitude of the vibration at different points around the circumference of a synchronous motor is shown in Fig. 1. (The nodes could be located easily by feeling the frame.) Measurements were made on the back of the punchings half way between the ends of the core. The results, however, would have been the same had they been made at any point on the same axial line.

In Fig. 2 may be seen the change of vibration amplitude as the supply frequency was varied, and the calculated resonant frequency for the motor frame. In making the calculation the punchings were added as dead weight but the armature copper was not included since it is probable that the slot clearance, flexibility of end windings, and damping effect of insulation may cause the effective mass to be zero or even negative. Similar tests were made after the machine was braced to add stiffness to the structure, the results of which also appear in Fig. 2. The reduction in vibration at the operating point (120-cycle) is worthy of note. The frame of this machine was not weak in comparison with frames of similar sizes and types but happened to have a natural period which gave unfortunate results.

In Fig. 3 is shown an exceedingly interesting curve with a dip in the center which was found to be due to end-bell resonance at that point. The violent oscillation of the rather light end-bells absorbed sufficient energy to decrease the frame vibration at what otherwise would have been its region of greatest amplitude. This illustrates the difficulties that face the designer in trying to predict his results, since calculation of the resonant point of a complex structure like an end-bell is practically impossible and since its likelihood of setting up objectionable overtones is great.

BIBLIOGRAPHY

1. Quiet Induction Motors, L. E. Hildebrand, A. I. E. E. Trans., July, 1930, Vol. 49, p. 848.
2. The M. M. F. Wave of Polyphase Windings, Quentin Graham, A. I. E. E. Trans., 1927, Vol. 46, p. 19.
3. Discussion of The M. M. F. Wave of Polyphase Windings, (Graham) P. L. Alger and W. V. Lyon, A. I. E. E. Trans., 1927, p. 58.
4. Vibration Problems in Engineering, S. Timoshenko, Van Nostrand Co., p. 297.
5. Vibration of Frames of Electrical Machines, J. P. Den Hartog, *A. S. M. E. Trans.*, 1927-28, Ap. M-50-11.
6. Natural Frequency of Gears, R. E. Peterson, *A. S. M. E. Trans.*, 1930, Ap. M-52-1.
7. Vibration Problems in Engineering, S. Timoshenko, pp. 234-267.

Elastic Supports for Rotating Machinery

By
E. H. Hull General Electric Company,
Non-member Schenectady, N. Y.

and

W. C. Stewart General Electric Company,
Associate A. I. E. E. Schenectady, N. Y.

NOISES ORIGINATING from electrical machinery are of two general types, namely, direct air noise, and noise transmitted through the machine foundations to the framework of the enclosing structure. (A. L. Kimball, *Journal of the Acoustical Society*, Vol. 2, No. 2, Oct. 1930, pp. 297-304.) Disturbances of the latter type often may be reduced by a properly designed elastic support between the machine and building.

Elastic supports can be made to isolate two types of disturbance; (1) shocks of any frequency typified by the automobile-spring suspension; (2) vibration of one or several known and constant frequencies. The supports described in this article fall into the second class and their function is to *isolate* not *absorb* vibration.

Effects of such a support may be demonstrated with the apparatus shown in Fig. 1: The mass M constrained to move in a vertical direction is supported through a spring k from the piston P which moves through a constant amplitude in approximate simple harmonic motion; M may be said to be elastically supported. At very low speed the weight moves through the same amplitude and in phase with the driving member. As the speed is increased the amplitude becomes larger, reaching a maximum at critical speed, then reducing as the speed is raised still more. At very high speed the weight appears to stand still in space. From this simple experiment it may be seen that the elastic support is not useful until a speed well above the critical point is reached.

In the case of an elastically supported machine "transmissibility" may be defined as the ratio of the force transmitted to the foundation to the disturbing force impressed on the machine. Fig. 2 shows that an elastic support is not beneficial until the ratio of impressed frequency to natural frequency of the system is greater than 1.41, and that when damping (frictional resistance to motion) is introduced the effectiveness of the support is lessened. See curves marked $b = 0.5$ and $b = 1.0$.

Values of transmissibility, beyond the speed range given in Fig. 2, and with zero damping, are given approximately by the square of the ratio of the natural frequency to the frequency of the impressed force.

MATERIALS AVAILABLE

Of the materials available for elastic support, such as metal springs, rubber, cork, felt, and gelatinous substances, a rubber compound containing a high percentage of pure rubber is at present found to be most suitable. Only small volumes of the material are necessary, the natural life is fairly long, damping is small, and protection from oil usually may be arranged. Once the elastic properties of rubber are understood, supports may be designed for nearly any combination of stiffness.

Noise and vibration of machines which may be transmitted through the foundation, and which may be isolated by an elastic mounting, fall into three general classes:

1. Vibration due to unbalance.

This occurs at rotational frequency which is usually below the audible range and hence does not cause noise directly, but may cause objectionable vibration of the foundations, resulting occasionally in rattles.

2. Bearing and brush noises.

Journal-bearing noise is negligible as is also brush noise in slip-ring motors. Ball or roller bearings may cause an objectionable disturbance.

3. Noise due to magnetic forces.

These forces are the greatest source of noise. In a-c. machines the fundamental noise frequency is twice the applied electrical frequency or 120 cycles for 60-cycle machines. Harmonics of this fundamental frequency and other high frequencies also occur but are of relatively less intensity.

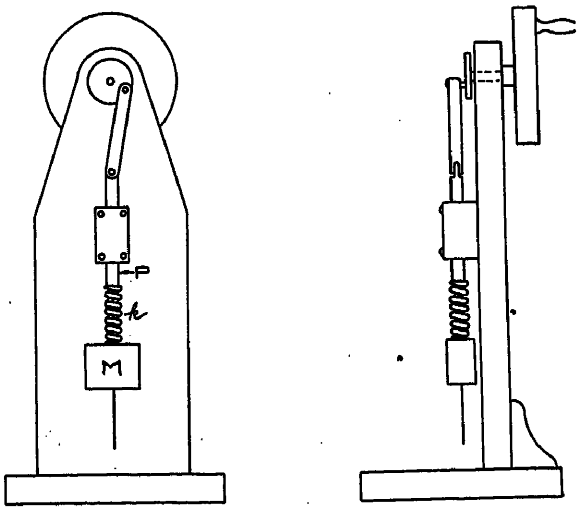


Fig. 1. Apparatus for demonstrating the operating principles of elastic supports

Elastic mountings capable of isolating this noise and these vibrations usually do not constitute a simple system, since in general there are six natural frequencies of the machine on its mounting. Mathematical expressions giving these frequencies have been developed and used to verify and predict resonances observed in elastically supported machines. The elasticity of the mounting must be adjusted to the machine so that none

---

From "Elastic Supports for Isolating Rotating Machinery," (No. 31-76) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

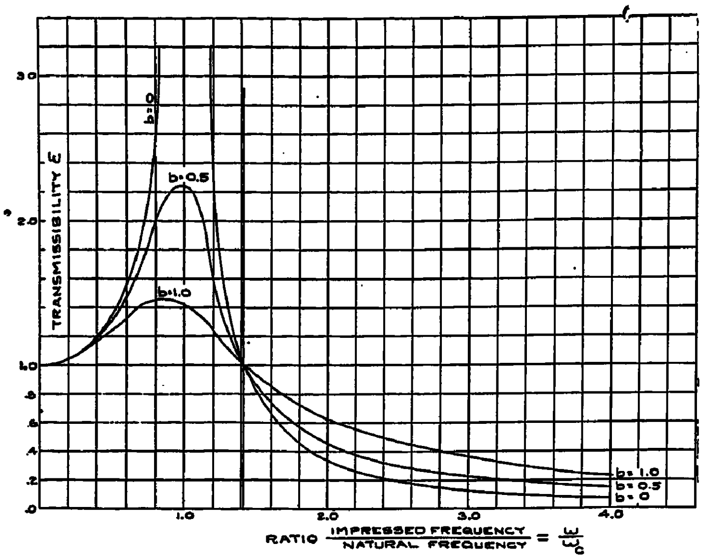


Fig. 2. Transmissibility curves for different damping constants

of these resonant frequencies coincide with that of any disturbing force, for should this occur both the vibration amplitude and the transmissibility would become large.

As stated, there is a wide variety of noise and vibration frequencies to be isolated. It may be shown that if a mounting is designed to isolate a certain frequency, the higher frequencies will be isolated more effectively. For this reason the high frequencies do not present any difficulty unless their amplitudes are greater than those ordinarily encountered.

The foundation upon which a machine is mounted affects to some extent its mounting design. At present, noise problems concern mainly installations in hotels, apartment houses, schools, and office buildings where the foundation is usually a concrete floor. This floor is most sensitive to forces transmitted from the motor in a vertical direction. These tend to bend the floor slab and for this reason the transmitted force normal to the floor should be given particular attention.

Damping is beneficial in the foundation as it reduces the amplitude of the floor vibration which is the source of sound radiation. Since the high frequencies are isolated best by the mounting and are damped most by the foundation, there usually remains as troublesome only the rotational and the fundamental magnetic frequencies.

Elastically-mounted machines may be separated into two classes depending upon whether they (1) transmit torque to apparatus on a separate base or (2) are self contained. Motor-generator sets are of the latter class. Here the stiffness of the support is not limited by the stability of the system against external forces such as belt pull; hence the vertical resonance can be made sufficiently low to isolate the unbalance vibration of the machine, which is the lowest frequency of disturbance present.

RESULTS

A number of motor-generator sets has recently been mounted with marked success on rubber pads. The stiffness of these pads is proportioned to give the set a material frequency in the vertical direction, sufficiently low to insure good isolation. Four pads are usually used, one under each corner of the base.

In the case of polyphase induction motors the magnetic vibration may be in any direction and therefore the stiffness of support for these machines must be low in all directions. On the other hand, the mounting must be sufficiently stiff to withstand belt pull which usually makes it impossible to isolate the low-frequency unbalance vibration. This vibration can be cured at its source, however, by an accurate running balance.

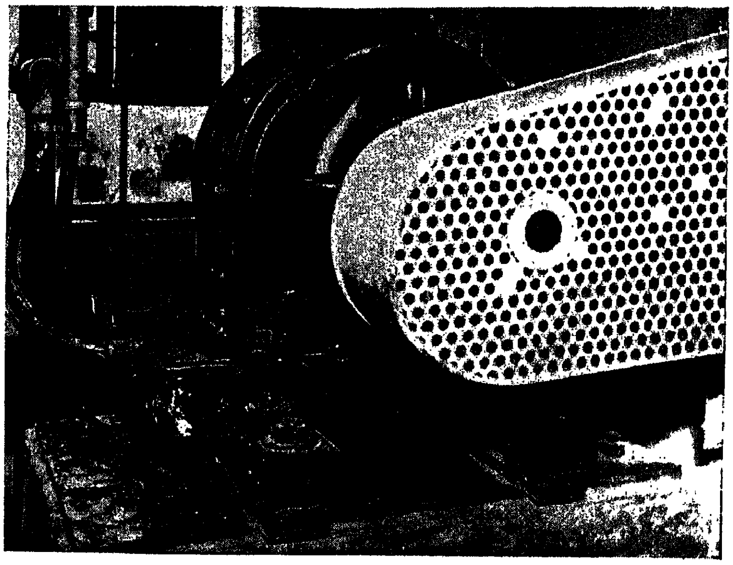


Fig. 3. Induction motor with rubber pad mountings

In Fig. 3 is shown mounted upon rubber pads a variable speed polyphase induction motor used to drive a ventilating fan in a large office building. No noise transmitted from the motor could be detected in the floor. The motor itself was stable throughout the speed range, vibrating through a maximum amplitude of only 0.002 in. at a low frequency due to force transmitted through the belt from the fan. This slight motion however is not objectionable.

This rubber mounting has been compared with all the usual types of elastic mountings by means of a specially prepared sound-box. A motor on the mounting to be tested is placed on top of this box; an observer enters the box and judges the effectiveness of the mounting by the amount of noise transmitted into the box. Results of these tests show that in the prevention of sound transmission the rubber mounting compares very favorably with any of the mountings tested thus far.

The more important results of the investigation may be summarized in the facts that,

1. Elastic supports are useful only when the ratio of the impressed frequency to the natural frequency of the system is greater than 1.41; a ratio of 2 or 3 is sufficient for unbalance vibration, while a ratio of 7 or 8 is necessary for noise isolation.
2. Since it causes increased vibration transmission, damping is undesirable in the elastic member of a support but is beneficial when present in the foundations.
3. If the mounting is designed to isolate low disturbing frequencies, the higher frequencies will take care of themselves.
4. In general, the mounting has six natural frequencies, none of which should occur within ten per cent of the running speed range.
5. For machines which transmit torque, the mounting must be sufficiently rigid in the direction of belt pull to allow stable belt operation.

Measurement of Machinery Noise

By
H. B. Marvin
Associate A. I. E. E.
General Electric Company, Schenectady, N.Y.

MACHINE NOISE INVESTIGATIONS should include vibration tests at various points on the machine and its support, as well as loudness measurements at various points in the surroundings pace. With the "audio noise meter" described in this article, both types of measurements can be made and information thus obtained is extremely valuable in the study of machine noises, their causes and remedies.

For loudness tests, the response of the measuring instrument should correspond with the loudness perceived by the ear. Accordingly a logarithmic scale in which loudness is expressed as the number of decibels[1] (for numbered references see bibliography) above threshold of audibility has been used for the loudness tests involved in this investigation. This choice of threshold or zero loudness as a reference point was made chiefly in order that the results would be comparable with published data on room and street noise.[2]

Reference is here made to a series of contours representing equal loudness which has been set up by Kingsbury.[3] (See Fig. 3 of "A New Meter for Noise Analysis," which appears elsewhere in this series). The contour which at 700 cycles is 30 decibels above threshold of audibility of the average ear has been used as the basis of the response-frequency characteristic of the audio noise meter, for total loudness tests. In the analysis of noise, frequency-weighting by the instrument is not necessary since only one frequency is considered at a time. Thus the loudness of each component is measured separately and referred to the equal loudness contours, a method which gives greatest sensitivity.

DESCRIPTION OF AUDIO NOISE METER

The complete analyzing noise meter is housed in three cases; one contains the measuring amplifier and has space to hold the sound pick-up and tripod; another contains the batteries, while the third contains the analyzer. With this arrangement the meter is portable and may be used with or without the analyzer. Schematic circuit diagrams of all three units are shown in Fig. 1.

The sound pick-up consists of a condenser microphone and a three-stage amplifier enclosed in a separate metal case. Power for the microphone amplifier is obtained from the battery unit.

The amplifier unit consists of a four-stage amplifier with calibrated output meter of the rectifier-milliammeter type, a calibrated attenuator, and an ear-compensation network. Scale and dial are marked in decibels. Tests have shown that over the range of the instrument the readings are closely proportional to loudness.

The analyzer may be connected between the sound pick-up and amplifier to obtain harmonic analysis of noises. This analyzer consists of an electromechanical filter (see Fig. 2) and in order to obtain complete separation of harmonics, it has been designed with high selectivity, yet sufficiently broad at resonance so that small variations of speed or frequency will not seriously affect its operation.

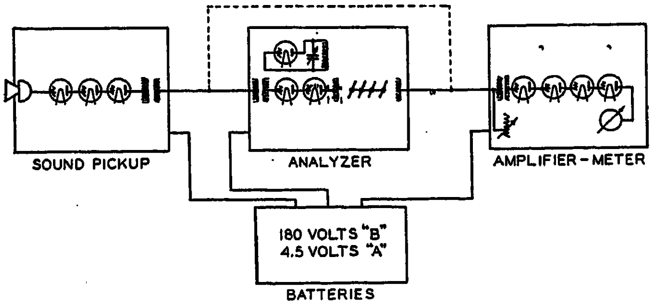


Fig. 1. Schematic diagram of audio noise meter

Complex current to be analyzed is passed through windings on the poles of a driving magnet and a sinusoidal current from a variable-frequency vacuum-tube oscillator is passed through an exciting winding of the same magnet. The resultant flux in the air-gap produces a torque on an armature or vibrator equal in

---

From "The Measurement of Machinery Noise," (No. 31-81) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

frequency to the difference between the complex wave and the analyzing sine wave, and proportional to the product of their amplitudes. The armature and its supporting stem are designed to have angular vibration resonance at 6,000 cycles. Four vibrators are tuned to the same frequency and coupled in tandem by wires under tension. A permanent magnet with pole windings is mounted in such relation to the fourth vibrator that the motion of the vibrator induces in the windings of the magnet a voltage proportional to its velocity of angular vibration. Mass and compliance of the vibrators and tension of the coupling wires are adjusted so that the combination has characteristics similar to an electrical band-pass filter.

In operation the frequency of the oscillator is varied slowly from 6,000 to 11,000 cycles. Whenever the difference between this and the frequency of a harmonic in the complex wave equals 6,000 cycles, the analyzer responds. The frequency range is therefore 5,000 cycles maximum, the minimum at present being 30 cycles. This heterodyne method of analysis has the important property of equal selectivity for all harmonics.

CALIBRATION

Laboratory calibration is made by comparison with primary sound standards on sine-wave tones of variable loudness and frequency. The instrument contains voltmeters for checking battery conditions but in addition convenient means are provided for an over-all one-point check which can be made in the field.

In the measurement of vibration a device is held against the machine which generates a voltage proportional to its velocity of vibration. This vibration pickup is substituted for the microphone so that both total vibration and harmonic-analysis measurements are possible. Since the noise is more often proportional to *velocity,* than to *amplitude,* of vibration, this measurement may be used to either supplement or even substitute for sound measurement.

RESULTS

Uses for an audio noise meter are manifold. For some work a total noise test is sufficient, as for example in comparing noise levels in factories or other noisy places, and in the acceptance testing of machinery. If tests are made with the idea of changing design, harmonic analysis is most useful. Fig. 3 shows an analysis of noise from a small synchronous motor in which the noise arises principally from higher harmonics (as high as the 74th) of rotational frequency which is 30 cycles. In synchronous apparatus nearly all noises are multiples of rotational frequency but in induction motors and other variable-speed machines there are usually two series, one based upon power-supply frequency and the other upon rotational frequency.

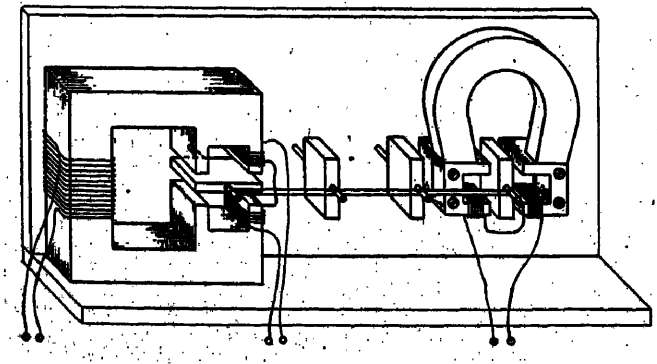


Fig. 2. Electromechanical harmonic analyzer

An analysis of hum from a 325-watt, 60-cycle, 110/1100-volt transformer was made with core clamps loosened, and applied voltage 20 per cent above normal in order to increase the amount and complexity of the resulting noise. Here the harmonics again fell into one series having a fundamental of 120 cycles per second. All harmonics up to the 15th were found to be present in a measurable amount but the fundamental was inaudible. Owing to imagination which would supply a fundamental in order to be logical this would probably not be surmised in a listening test. The effect of loading the transformer was to decrease the total noise, but analysis showed that some harmonics (notably second, sixth, and tenth) were weakened much more than the average.

CONCLUSIONS

Although knowledge of the sense of hearing is still far from complete it is felt that the instrument described serves a very useful purpose in studying machinery noise, the manner of its generation and transmission, and its composition and magnitude.

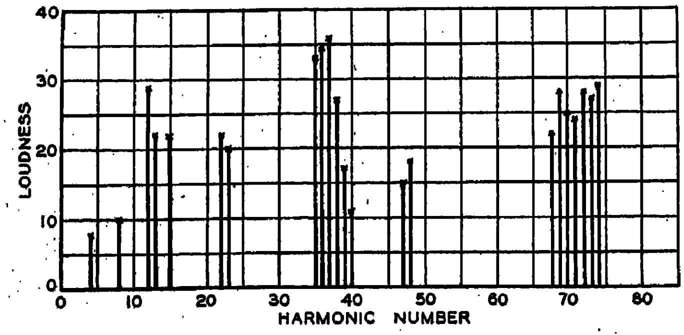


Fig. 3. Analysis of noise from a ¼-hp., three-phase, 60-cycle, 220-volt, 1,800-r.p.m., synchronous motor at no load. The fundamental of the series is rotational frequency or 30 cycles per second

The analyzer has a high degree of selectivity, is convenient to operate and, combined with sound and vibration pick-up devices, enables quantitative analyses to be made on electrical, mechanical, and acoustical waves.

Bibliography

1. Decibel—the Name for the Transmission Unit, W. H. Martin, Journal A. I. E. E., March 1929, Vol. 48, p. 223. Also *Bell Tech. Jl.*, Jan. 1929.
2. A Survey of Room Noise in Telephone Locations, W. J. Williams and Ralph G. McCurdy, A. I. E. E. Trans., Oct. 1930, p. 1393.
3. A Direct Comparison of the Loudness of Pure Tones, *Physical Review*, 2nd Series, 1927, Vol. 29, p. 588.

Mitigation of Substation Noise

By
E. A. Bishop
Associate A. I. E. E.
Commonwealth Edison Company, Chicago, Ill.

NOISE REDUCTION IN SUBSTATIONS has in most cases taken the form of confining the noise within certain reasonable limits rather than eliminating it at its source. In accomplishing this, however, other complications are introduced, especially as regards ventilation.

The following classes of substations are discussed in the order named:

1. 230-volt d-c. station located in a downtown district.
2. 600-volt d-c. station for traction service.
3. 1,500-volt d-c. station for electrified railway service.
4. A-c. remote-controlled distribution station.

D-C. Converter Stations

Since the problem of noise due to synchronous converters is common to three of the types of substations mentioned it may be well to discuss it first. Noise emanating from converters is related directly to speed and frequency and in general may be classified as follows:

1. D-c. commutation noise where the brushes riding on the commutator bars and the slots passing under the brushes are contributing factors. High-mica or commutator bars may in addition set up an objectionable chattering noise.
2. Windage, which depends upon the speed of the machine.
3. Magnetic noises which are usually so low-pitched that they are drowned out by other noises.
4. A-c. brush and slip-ring frictional noises.
5. Vibration of the building housing and equipment. This is rather unusual and occurs chiefly if the unit, for any reason, should run on "open phase."

The first measure toward the reduction of converter noise was to provide as a part of the unit a semi-enclosure consisting of a sheet-metal housing with wire glass doors and windows enveloping the d-c. end of the machine. However, when any attempt is made to enclose a converter, a secondary problem of ventilation immediately becomes manifest. In the case of the semi-enclosures this was cared for by leaving an opening in the front end of the housing approximately the same size as the opening inside the commutator. Cool air was then drawn into the armature through the commutator, passed through the ventilating slots of the armature core and windings and discharged through a chimney at the top of the enclosure. In some cases this chimney was connected to a point outside the substation by means of a duct; in others it simply discharged into the converter room. These semi-enclosures effected quite a reduction in noise, but were not satisfactory from either a standpoint of ventilation or accessibility.

The next step was to completely enclose a 600-volt railway converter when the residents in nearby apartment houses objected to its noise. This enclosure consisted of a wall of ½-in. transite supported on a structural steel framework. The inside of this enclosure was lined with 1-in. asbestos hair felt. A baffled chimney on top of the housing permitted the air to be discharged, and deadened a large part of the noise.

From a noise reduction point of view the total enclosure was fairly successful since it eliminated the complaints, but protection against heating was quite a serious problem and required the installation of a blower to force cooling air through the housing. A new problem presented itself when flashovers occurred and small particles of hot copper or carbon were discharged into the hair felt lining. This material did not burn rapidly but due to the draft would smolder, making it necessary to use a fire extinguisher. This was overcome by placing a second lining of ⅛-in. porous asbestos paper inside the hair felt. The net result was satisfactory although the relatively poorer noise absorbing quality of the thin asbestos slightly decreased the over-all noise reduction.

Success in this experiment resulted in the continued development of the total enclosure, which along two general lines is now designed by the two principal manufacturers. The first consists simply of a cubical housing completely enveloping the entire converter, the dimensions being such that the sides are a few inches clear of the machine bedplate at all points. A partition at the main field yoke divides the housing into two sections. Air for ventilation is admitted at the d-c. side of the unit through openings in the foundation, and is discharged through a chimney located in the top on the a-c. side, a blower being required on either the intake or discharge side to circulate the air.

The second design, while completely enveloping the converter, conforms to the general shape of the unit, and is rounded off at the top. The method of ventilation is identical with the first design.

Compared to the semi-enclosures, these total enclosures have the advantages of greater noise reduction,

---

From "Noise Mitigation in Substations," (No. 31-73) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

better ventilation, and more space available for maintenance and minor repairs. It should be mentioned, however, that complete disassembly is required for major repairs and due to the elaborate ventilation facilities required an added initial cost is involved.

In a recent installation there arose the problem of noise being communicated to adjacent parts of a large building in which was located a theater immediately over the substation. The following measures were taken to provide a quiet installation:

1. The converters of course were completely housed.
2. Converters and transformers were supported on cork insulated foundations.
3. Blowers and motors were likewise mounted on cork foundations.
4. Connections to the air-exhaust ducts were made with a canvas joint.
5. Flexible laminated copper strips were used for the main d-c. terminal connections.
6. To further eliminate the possibility of vibration being communicated along the main copper connections and in turn through the supports to the building steel, several flexible joints were made in these long runs.

The installation has been in service two years and has proved satisfactory in every way.

At the present time, there is under consideration the problem of noise mitigation in 1,500-volt traction substations. The units installed consist of two 750-volt machines with commutators connected in series. They run at a speed of 600 r. p. m. and give rise to an extremely high-pitched penetrating noise. This noise consists principally of two elements; one due to commutators and the other to windage. It is not considered feasible to totally enclose these units because of the hazards which would result from flashovers. A new form of pole tip has been designed, however, to reduce the whistling noise produced by the field poles but as yet no authentic data are available regarding the reduction of noise actually attained.

Before leaving converting equipment it should be stated that from a noise mitigating standpoint, the mercury arc rectifier is the most satisfactory device so far developed. Its operation is silent except for the hum in the associated transformer and the noise of the rotary vacuum pump. The latter device has been much improved since the original installations and is now satisfactory.

A-C. SUBSTATIONS

In a-c. distribution substations, the character of the noise produced is entirely different, consisting chiefly of hum having a fundamental frequency of 120 cycles which is inherent in transformers and induction regulators. The noise in these substations while not nearly as intense as in d-c. stations is nevertheless somewhat above the noise level of residential neighborhoods. In one substation, this noise was found to be transmitted through building steel to the outside walls and thence to an adjoining apartment house. This difficulty was overcome by placing cork under the transformers and regulators, and replacing the rigid terminal connections with flexible ones.

Transformers installed outdoors in remote-controlled substations have been the cause of serious complaints. As a rule, they are installed in an open court adjacent to the building which houses switching equipment and regulators. In a typical case this court consisted of brick walls along the side and one end with a wire mesh screen at the opposite end; the brick walls contained small openings for ventilation. In this case the major part of the noise was confined to the court by placing sound-absorbing felt over the wire-mesh screen and constructing a roof of sheet-metal arc-shaped sections having the under side covered with sound-absorbing felt. These sections were arranged so as to baffle the sound waves and at the same time permit free passage of air.

In summarizing the situation, at least so far as rotating equipment is concerned, very little has been accomplished toward reducing the noise inherent in the machines. Practically all efforts up to the present time have been toward confining the noise to the equipment and in solving the incidental ventilation problems.

Noise from Induction Regulators

By
J. P. Foltz Associate A. I. E. E. — Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
and
W. F. Shirk Non-member — Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

AN IMPORTANT PREREQUISITE to the study of noise in induction regulators is the establishment of a method for making quantitative noise measurements. Surroundings have a very great effect on the values of sound intensity; thus for consistent results all sound measurements should be made under identical conditions as regards not only background noises but also surfaces in the vicinity. Induction regulators, however, are usually difficult to handle and it is therefore quite inconvenient to move them to a place suitable for making sound measurements.

Since surface vibration is the chief cause of noise in induction regulators and since this vibration bears a quantitative relation to the sound produced, many of

---

From "Induction Regulator Noise," (No. 31-84) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

the difficulties experienced in making suitable sound measurements can be obviated by measuring vibration instead. Special surroundings are not required for vibration measurements; with a minimum expenditure of time direct comparison of machines is possible on the test floor during working hours. It is possible also to make representative measurements on the various elements of a machine, tracing vibration to its source and determining the effect of different conditions upon that source.

Noise produced by induction regulators and transformers is quite simple in character as compared with noise produced by rotating machinery. The noise (exclusive of clicking of relays during the period of voltage adjustment) has a fundamental frequency double that of the supply voltage and is radiated directly from the tank walls, cooling tubes, and boxes housing the control panels fastened directly onto the side of the regulator. There may be present harmonics of the fundamental depending on the supply voltage, but usually these are not large.

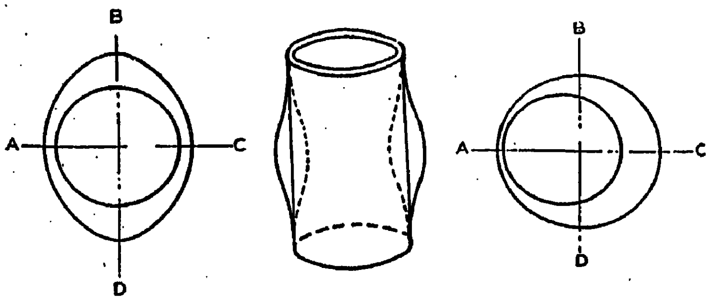


Fig. 1. Illustrating in exaggerated form some factors affecting stator vibration. From left to right, elliptical deformation of the stator by field forces; vibration of stator under radial forces of field; rotor out of center with stator

Experience gained on small single-phase regulators in the past has indicated that invariably noise could be reduced by a well-balanced gap and small clearances in the bearings; however, more recent experience with larger machines has shown that there are several types of vibration (especially in larger regulators) which no degree of accuracy as to mechanical fitting and centering will cure.

According to the source, (See Fig. 1) regulator vibration may be divided under the following three headings:

1. "Hoop vibration" caused by the radial forces set up by the magnetic flux across the air-gap. Since this force is balanced its only effect in the two-pole regulator is to deform the stator into an ellipse with minor axis corresponding to maximum of flux wave. The result of this deformation is a vibration of the stator in a radial direction and is transmitted directly through the oil to the tank.

2. Vibration due to the rotor being out of center or eccentric with regard to the stator. In this case the forces on either side of the rotor are not balanced and there is a resultant force tending to vibrate the rotor and stator as beams supported at the ends. This vibration is transmitted to the tank partly through the top and partly through the oil directly from the stator.

3. Torsional vibration. This is evident in some single-phase regulators, and is carried to the cover through the worm and segment. While this type does not contribute much to the noise directly, if of sufficient magnitude it is liable to cause impact between worm and segment, with a resultant rattle that is quite objectionable.

These types of vibration are all of the same frequency but in any consideration of causes it is necessary to distinguish between them.

The more important type of vibration in large three-phase two-pole regulators is that produced by the elliptical deformation of the stator under the action of the field (hoop vibration). In small machines the stator rigidity is sufficiently high to limit this vibration to a point where the other types of vibration become of importance.

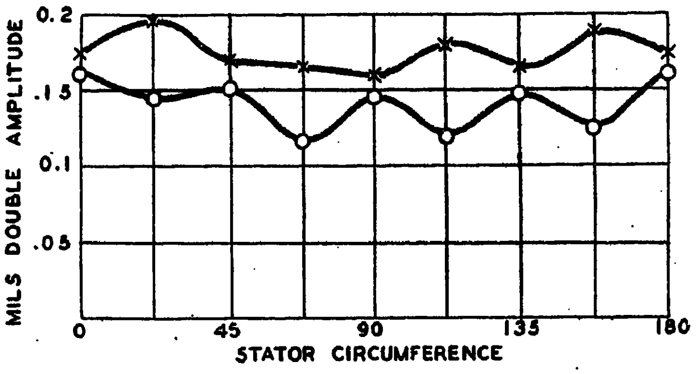


Fig. 2. Relative vibration amplitudes measured on circumference of core (x) and frame (o) of a typical regulator

In designing regulators it is desirable to calculate the probable amount of vibration that will be produced in the finished machine. It is possible to do this approximately by the usual theoretical formula (*Etude Meneanique Et Uswage Des Machines Electriquet,* by H. DePistoye, p. 560) provided certain assumptions and approximations are made.

In the case of hoop vibration the annular rigidity of the stator is the controlling factor so that the amplitude of vibration is the same as the static deflection under the load produced by the force of the field. In a three-phase regulator the field is fairly well distributed but it may be considered as having a sine wave of distribution. For example in a representative three-phase two-pole regulator the double amplitude of vibration was calculated to be 0.14×10^{-3} in. The measured double amplitude on this same regulator (average of several readings) was 0.19×10^{-3} inches.

If the rotor is slightly eccentric in the air-gap the forces of the field on either side of the stator do not balance and the rotor is deflected toward the narrower gap. Vibration having a frequency double that of the supply voltage is set up adding to the hoop vibration on one side and subtracting on the other. The vibration of the rotor is carried to the covers and thence to the outer tank surface. In practise, however, it is quite possible to keep the eccentricity low enough on most large regulators to keep this type of vibration within limits.

Torsional vibrations of the rotor, (due to flexibility in the shaft and worm), are controlled by the mass reaction of the rotor. This type of vibration is not important except in small regulators and large 25-cycle regulators. Torsional vibration does not usually contribute much to the noise directly, but in the worm and segment is a system which has a variable spring constant so that higher frequencies may be introduced due to impact between worm and segment. These lie in the range of greater ear sensitivity and are very objectionable. The introduction of flexibility between rotor and segment or between worm and cover eliminates this difficulty by preventing the vibration from reaching the cover.

While the vibration has its chief origin in the stator core it must pass through the oil before it can affect the tank wall and thus be radiated as sound. The oil is nearly incompressible, however, and thus serves as an excellent medium for transmitting the vibration to the tank. The tank, however, does not follow the core but appears to have on the surface a number of locally resonant regions whose positions are not at all definitely determined. As a result and in order to compare machines, it is necessary to take a number of readings both in a vertical and horizontal plane and obtain an average.

Since cooling tubes are liable to be resonant in themselves their presence further complicates the action of the tank wall. This tube resonance should be guarded against not only on account of noise but because, due to the large amplitudes that occur at resonance, it is likely to fatigue the weld where the tube enters the tank and create an oil leak. In these tubes one may find anything from nearly rigid support to nearly perfect flexibility at end welds. In order to be safe then it is necessary to work outside the region between these two extremes. This resonance region can be computed by consideration of weight of tube full of oil, inertia of cross-section, and length. It is then the problem of the uniformly-loaded beam. Where the tubes are supported one upon another or on the tank at any place other than the end, the problem becomes indeterminate analytically.

With information gained from vibration measurements and some knowledge of the magnetic, electrical, and fundamental mechanical conditions in the general type of structure represented by the induction regulator, it is possible to classify regulator noise according to its source, determine the relative importance of each class in different sizes and types of regulators, and even calculate approximately what to expect from a new design.

Impulse Tests Made on Substations

By *R. N. Southgate*
Associate A. I. E. E.

A. S. Brookes
Associate A. I. E. E.

Public Service Electric & Gas Co.
Newark, N. J.

E. R. Whitehead
Associate A. I. E. E.

W. G. Roman
Associate A. I. E. E.

Westinghouse Elec. & Mfg. Co.
East Pittsburgh, Pa.

Unlike many lightning and surge investigations which have largely concerned individual pieces of apparatus, the tests outlined here have been made on complete substation units. Qualitative results have been obtained for two classes of stations.

DURING the past few years a great deal of experimental work has been carried on in studying the nature of disturbances due to lightning, and in determining transmission line characteristics, with a view to forecasting the behavior of transients of this nature on transmission systems. To date, experimental work on terminal equipment has been largely confined to the study of individual units; in the summer of 1930, however, the opportunity to study surge behavior on typical substation layouts presented itself. The tests described were made with the aid of cathode ray oscillograph and portable lightning generator equipment of the Westinghouse Company.

An effort was made to check graphically some of the theories generally accepted in regard to the action of a traveling wave striking typical substation structures, in the expectation that the results might serve to clarify general protection problems. It was realized that actual layouts vary greatly, and that test results must depend largely upon the type of station under investigation; also upon the chosen impulse wave. For these reasons, the results secured are largely qualitative in nature.

These tests were made in New Jersey on the system of the Public Service Electric and Gas Company where

---

From "Impulse Tests on Substations," (No. 31-44) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

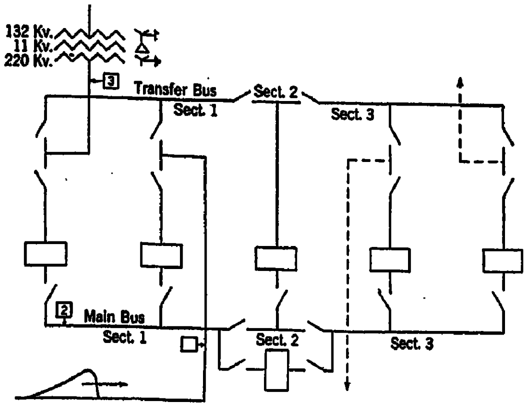


Fig. 1. 220-kv. bus layout at the Roseland substation

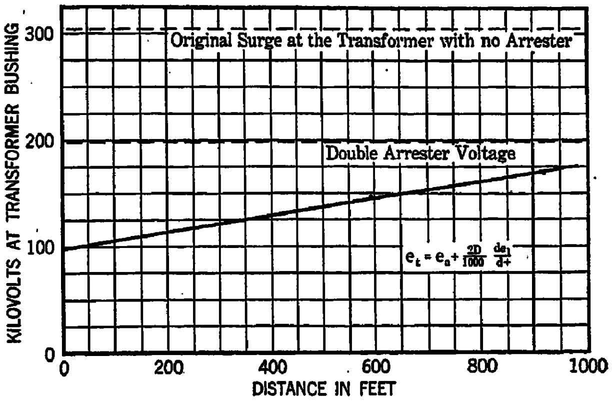


Fig. 2. Variation of impulse voltage at transformer terminals in the Roseland station, as affected by the distance between transformer and arrester

two types of substation structures were made available. The first series of tests was made on the 220-kv. bus and transformers at the Roseland switching station, a typical substation of the high-voltage class; the second, on the structures of the Elizabethport 26.4-kv. distribution substation.

The Roseland station is the terminal point of two 220-kv. interconnections feeding a 132-kv. ring which connects the other switching stations of the system. The 220-kv. structures, while complete, had not yet been placed in service.

A schematic diagram of the 220-kv. bus layout may be seen in Fig. 1. The entire bus, all oil circuit breakers, and one of the transformer banks, were available for connection to one incoming 220-kv. line. To secure a general idea of the distances involved, the conductor length from the terminal of the line to the main bus is about 300 ft. and from the bus to the transformer 330 ft. Main and transfer buses are both 270 ft. in length. The transformer bank consists of three single-phase, 30,000-kva. units connected *Y*-*Y* with solidly-grounded neutral on both 220- and 132-kv. windings.

Surges were set up by means of the portable lightning generator, located at a distance of eight line-miles from the station. This generator was adjusted to give at the station a traveling wave having a crest of 169 kv., a front of 5.5 microseconds, and a time-to-half value of 19 microseconds. A short surge of 4 microseconds in length with a crest of 140 kw. was obtained by chopping the longer wave by sphere-gaps connected to the line near the surge generator.

It was first desired to determine the modification of wave shape at the station as compared with the wave shape with the line end open. For this purpose volt-time oscillograms were taken at the line terminal and at the transformer with the line connected to (1) the transfer bus alone, (2) section 1 of the main bus, and oil circuit breakers, and (3) to the complete main and transfer buses and all oil circuit breakers. The effect of connecting the transformer to the station network was also investigated.

Table I shows the reduction in crest voltage in per cent of the open-end voltage for each of the foregoing conditions. In general, the crest of the transient is reduced as more and more bus is added to the circuit, and connecting the transformer caused a further decrease. It may be noted that the reduction was somewhat less for the long wave than for the short wave, and it is to be expected that a still smaller reduction would result from longer waves.

TABLE I—REDUCTION IN IMPULSE CREST VOLTAGE FOR DIFFERENT STATION CONNECTIONS

	Per cent reduction of crest kv.	
Station conditions	19 microsecond wave	4 microsecond wave
Section 1 transfer bus	4.5	
Transformer connected	11.2	32.0
Section 1 main bus line and transformer breakers	5.6	
Transformer connected	14.0	45.0
Complete main and transfer buses all breakers	24.0	
Transformer connected	35.0	65.0

It was desired also to determine how the distance between the point of location of a lightning arrester and the transformer bushing, would affect the voltage at the transformer. The arresters used for these tests were 25-kv. line-type porous-block units. Oscillograms of transformer voltage were taken for three different locations of the arrester; namely, at the transformer bushing, on the main bus 595 ft. from the transformer, and at the line terminal 920 ft. from the transformer. Results of these tests are shown in Fig. 2. It was found that if only one arrester were connected to a single bus leading directly to a transformer, the voltage at the arrester location will be a minimum; the voltage at any other point will depend upon the arrester's rated voltage, the rate of rise of the traveling wave, and the distance from that point to the arrester. With certain

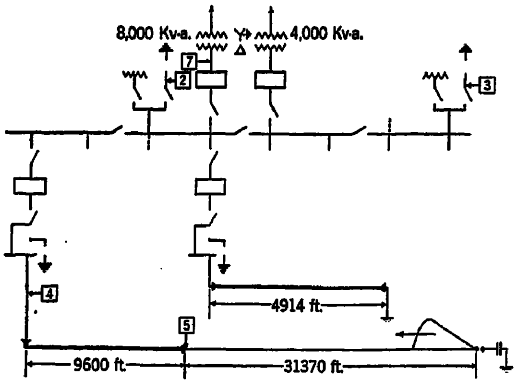


Fig. 3. Layout of bus and lines at the Elizabethport 26.4-kv. distribution station

approximations, the equation of the curve is given by the formula,

$$e_t = e_a + \frac{D}{1000}\;\frac{2\,d\,e_1}{d\,t}$$

where e_t = voltage at the transformer (in kv.)
e_a = arrester's rated voltage (in kv.)
e_1 = crest voltage of traveling wave on the bus (in kv.)
D = distance from arrester to transformer in ft.
$\frac{d\,e_1}{d\,t}$ = kilovolts per microsecond

TESTS AT ELIZABETHPORT SUBSTATION

The Elizabethport substation is designed to receive energy from eight 26.4-kv. cable feeders, and to distribute this energy at 4,150 volts. A schematic diagram of the station layout is shown in Fig. 3. Two of the 26.4-kv. feeders were available for test purposes; also two banks of transformers, the first consisting of two 4,000-kva., three-phase units, and the second a single 4,000-kva. unit. The station bus is about 150 ft. in length.

The line used in the impulse tests extends from the power station for a distance of about six miles in aerial conductor on wood poles to a point 9,600 ft. from the substation, where it enters underground cable leading to the substation bus. In order to secure sufficient distance for establishing a traveling wave effect at the cable pothead, the surge generator was located at the far end of the open-wire line. The cathode ray oscillograph was located at the substation where it could be connected to any point in the outdoor structures.

Connecting bus and transformers to the cable was found to reduce the crest voltage of the waves below the open-end value. A less pronounced modification would be expected here than at Roseland because of the smaller bus capacity and cable impedance. Measurements showed a reduction of only about 5 per cent as compared with the 35 per cent reduction which occurred at the 220-kv. switching station.

In the study of protection to station equipment arresters were placed at three different locations, and the voltage at the transformer measured for each location. Due to limitations on voltage imposed by the insulation of the open-wire line, the maximum test voltage obtainable at the station was about 30 kv. For this reason the arresters used were 6-kv. station type, which had a breakdown voltage sufficiently under the incident crest voltage to secure comparative results.

The arrester locations chosen were (1) the transformer bushing, (2) the main bus 90 ft. distant from the transformer, and (3) the main bus 150 ft. from the transformer. The maximum voltages recorded at the transformer for these positions of the arrester were respectively 21, 23.5, and 25 kv. From these results it is obvious that the problem of properly locating arresters in a station of this size is relatively simple.

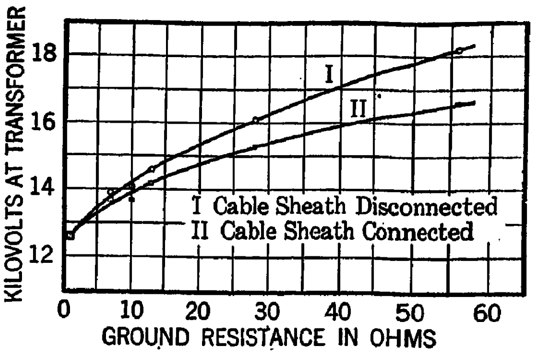


Fig. 4. Impulse voltage at transformer terminals in the Elizabethport station with arrester located on open line at various distances from the cable pothead

Another problem under investigation at this substation was to determine an effective arrester location for a point outside the station, at or beyond the cable pothead. The locations chosen for test were at the pothead itself, and at several points on the open wire at distances of from 300 to 3,300 ft. from this point. Arresters used were of the 6-kv. line type as before. Ground resistances at this location were quite favorable varying] in actual value from only about 0.5 to 1.5 ohms.

Results of these tests may be seen in Fig. 4. Due to the decreased conductor surge impedance at the cable pothead, the voltage at this point was insufficient to cause the arrester to breakdown. It may be noted that the impulse voltage at the station decreased as the arrester was moved away from the pothead, the slope of the curve decreasing considerably at about the 1,000-ft. point.

SUMMARY

Summarizing the more important results of both series of tests, it can be said that:

1. The capacity to ground of the bus and circuit breakers in large substations tends to reduce the impulse terminal voltage. In general, the effect of connecting transformers to the bus system is a further sloping off of the wave-front and reduction of the crest. The total effect is more pronounced in the case of very short waves, but appears to be appreciable for those of even moderate length.

2. When lightning arresters are placed on the bus, the voltage at the transformer will be greater than that at the arrester by an amount depending upon the steepness of the lightning transient, the arrester breakdown voltage, and the circuit distance from the arrester to the transformer. Oscillograms show results in agreement with calculations. For any given arrester location the seriousness of such over-voltages decreases with increasing arrester-voltage rating. For minimum impulse voltage, the arrester should be connected to the transformer bushing.

3. Because of the low terminal capacity and low surge impedance of entering feeders in small substations fed by cables, the capacity of the bus and connected apparatus causes only a relatively small decrease in the impulse-terminal voltage.

4. When a lightning arrester is placed on an aerial line joining a long cable leading to a substation, the station protection for a surge originating beyond the arrester is increased as the arrester is moved away from the junction along the open wire. This increase in protection is greatest for the first 1,000 ft. the arrester is moved out from the pothead. The exact arrester location must be selected also with due consideration to the possibility of a lightning stroke between the pothead and the arrester.

5. High ground resistance is found to decrease materially the protective value of line arresters; where this condition exists, arrester performance can be improved by connecting the high-resistance ground directly to the cable sheath. Economic considerations will decide where such a measure should be adopted.

Artificial Sunshine for the Modern Office

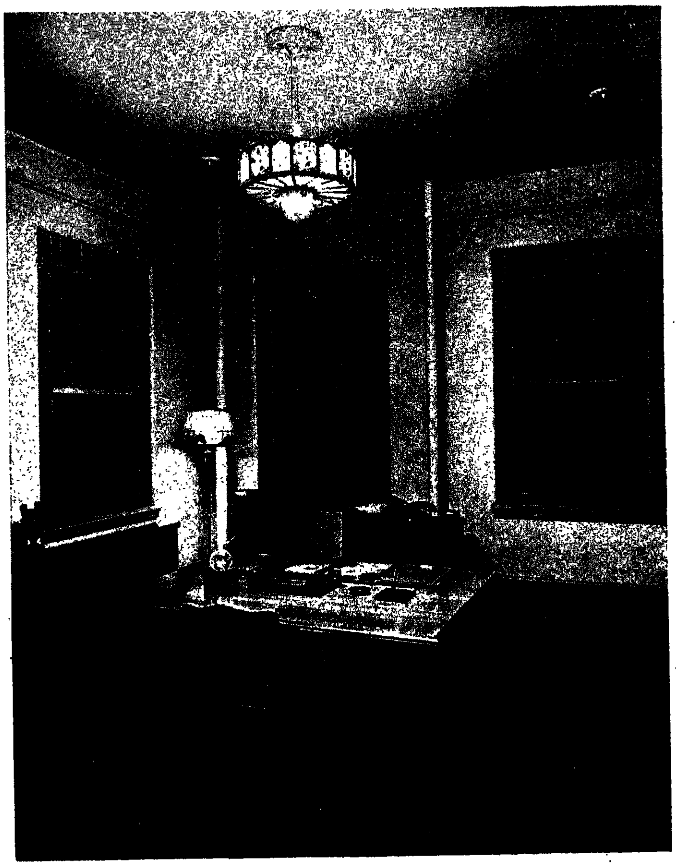
OFFICE SUNSHINE is provided by a special dual-purpose ceiling fixture recently designed for his office by M. Luckiesh, director of the General Electric Company's lighting research laboratory at Nela Park, Cleveland. A similar fixture is installed in the office of the president of the Cleveland Electric League.

These pioneer dual-purpose luminaries supply approximately 80 foot-candles on the desk top without creating a feeling of "too much light." Relatively few offices have artificial light intensities even as high as ten foot-candles and offices with 30 foot-candles are rare. The lighting shown is pleasing and comfortable, and the ultra-violet radiation has the same health-maintaining characteristics as outdoor summer sunshine.

This particular lighting fixture has an upward or indirect lighting component supplied by eight 100-watt incandescent lamps equally spaced in the upper portion connected to two circuits. This alone supplies a general illumination of 10 foot-candles. The downward component of light and the ultra-violet radiation are produced from one "sunlight" lamp (S-1) in the center of an oxidized aluminum reflector equipped with baffle-rings which control the light distribution and ultra-violet radiation and which shield the eyes from direct view of the S-1 lamp.

Like the portable sun lamp, this fixture necessitates the use of a transformer, and in this particular unit it has been conveniently located in the ceiling directly above the canopy.

In buildings where the space between floors will not permit the recessing of a transformer, it is possible to run heavy wires from the fixture to a point convenient for the location of the transformer. This wire should not be smaller than:



Eighty foot-candles of healthful light on the working plane in this office

No. 10 B & S gage for distances up to 15 ft.
No. 8 B & S gage for distances up to 25 ft.
No. 6 B & S gage for distances up to 40 ft.
No. 4 B & S gage for distances up to 60 ft.

Like the studios of the National Broadcasting Company in Chicago where ultra-violet radiation is supplied from overhead units, these office fixtures are creating much interest in the minds of all who have had the opportunity to see them.

Automatic Arc Welding

By the use of arc welding, marked savings have been effected in the manufacture of electrical apparatus. Automatic control for this process has made possible still greater savings and at the same time better and more uniform products.

By G. H. Koch

General Engineer
Westinghouse Electric & Manufacturing Company

ARC-WELDED PRODUCTS and their many advantages over the castings and riveted structures, which they superseded, have been discussed quite thoroughly in various recent publications. The manufacturers of electrical machinery were among the first to take advantage of the flexibility and liberties of new design afforded by the arc-welding process. Automatic control is now being applied to this type of welding and the great saving of time over that required for hand operation is resulting in lower production costs for parts so manufactured.

Where manual welding is employed, the trained welder replaces the trained foundryman or the skilled riveter in obtaining the final results. In both the old and the new processes, then, the quality of the product is as much dependent upon the care and vigilance of the artisan in overalls as upon the judgment and slide rule of the designer. The functions performed by the trained welder were found to be particularly suited to reproduction by machinery. The arc voltage must be maintained at a constant value and the electrode feed towards the arc should be as uniform as is consistent with a constant arc voltage. The progress of the arc along the seam should be steady and at a fixed rate.

In an automatic arc-welding machine an electric motor is used to feed the electrode at the required rate to maintain a constant arc voltage between the electrode and the work. A machine of this type is shown in Fig. 1. As may be noted, the electrode passes through a long nozzle after it leaves the driving rolls and emerges at the lower end to be fused in the arc and deposited on the work. Welding current enters the electrode through the sliding contact in the nozzle.

Elements sensitive to arc voltage automatically regulate the direction and speed of the welding electrode and serve to maintain the arc voltage constant even on an irregular surface. Separate motor-driven devices provide a uniform motion of the arc along the seam and a weaving motion across the seam where this is desired. After the current value, arc voltage, and travel speed are selected for a given job, the operator is required only to start and stop the welding operation, and to change the work. In some high-speed production work even these operations are performed automatically.

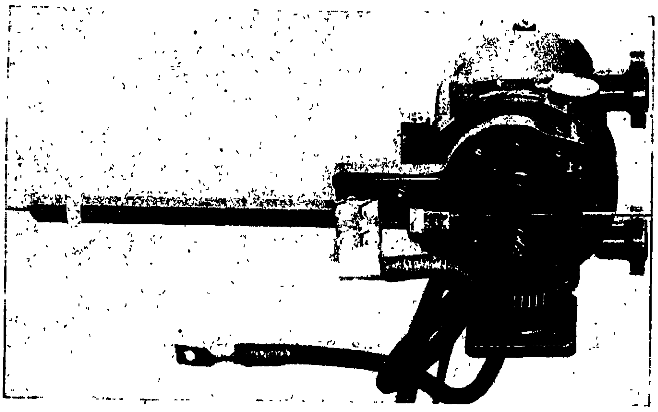


Fig. 1. Automatic welding head showing electrode feed mechanism

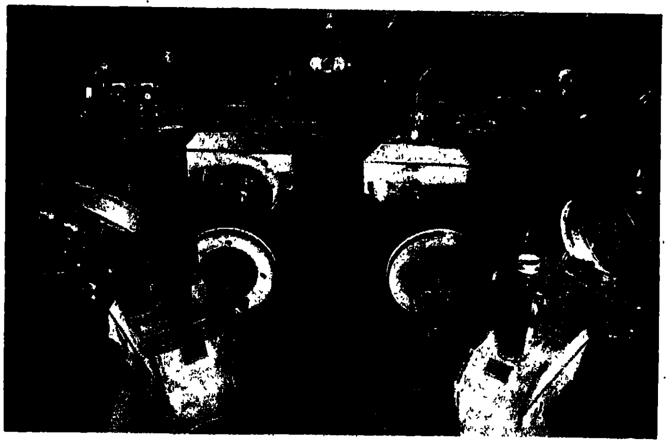


Fig. 2. An installation of four automatic welding heads for building up worn car-wheel flanges

As a general rule on any given job only slightly larger electrodes are used for automatic welding than for hand welding. Increased welding speed is brought about largely by the fact that a higher current density in the electrode is possible in automatic welding than in hand welding. About 25,000 amperes per sq. in. of electrode section is common in automatic welding compared with 10,000 amperes per sq. in. in hand welding. This increased current concentration provides for better fusion and improved arc stability. Usually less deposited metal is required in automatic welding because

---

From a paper presented informally at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

of this factor and because of the greater general reliability. Furthermore, since the electrode is fed continuously from a reel, there are no interruptions such as the manual welder introduces in changing electrode rods. All of these factors tend towards increased speed and better welds.

The comparative welding speeds for automatic and manual arc welding are now fairly well known for existing commercial electrodes. In general it may be said that simple, continuous welds may be made with an automatic welding head in from one-third to one-sixth of the time required by an expert manual welder, depending upon the thickness of material.

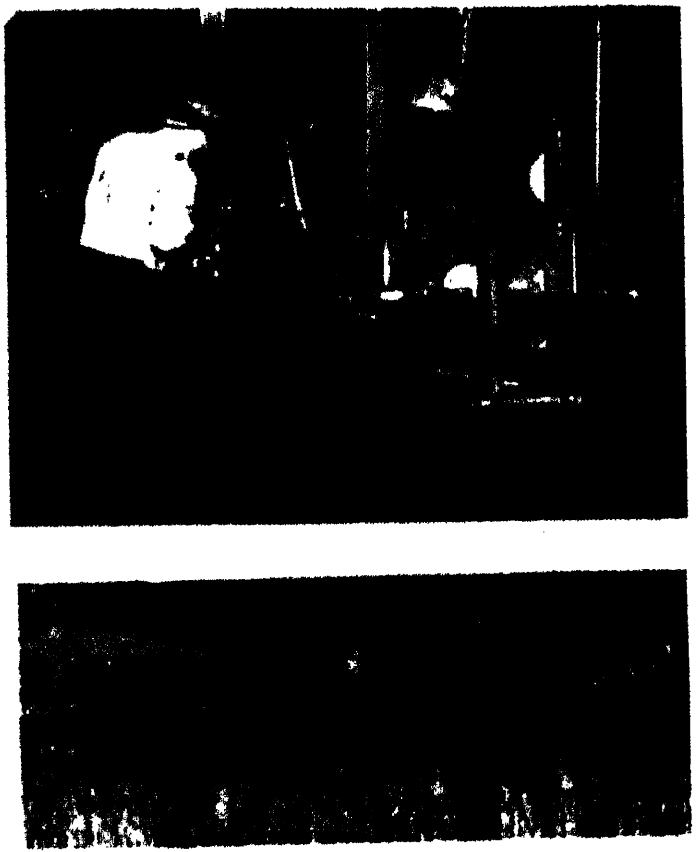


Fig. 3. Special clamp (above) for holding tank sheets and tubes during welding process. Note thickness of material in finished weld, (below)

One of the earliest applications of automatic welding in the electrical industry was in connection with the repair of worn flanges on steel street-car wheels. Unless the worn section is built up by welding, an excessive amount of material must be cut from the face of the wheel to restore the proper face contour. An installation of four automatic-welding heads in a large street railway repair shop is shown in Fig. 2. One man can keep the four automatic arcs in operation, thereby doing the work of twelve manual welders. The automatic weld sets up much lower shrinkage stresses in the wheel than a manual operation since a large number of beads are added successively at a relatively high speed thereby providing uniform heat distribution.

Automatic welding next was introduced into the manufacture of sheet-steel tanks for transformers and circuit breakers. A seam-welding clamp used to make longitudinal butt and lap welds in round, elliptical, or rectangular tank shells is shown in Fig. 3. A large shell or a number of small ones is held against a backing bar by air-pressure clamping fingers and the weld is made by the automatic head which is mounted on the traveling carriage. Mounted also on this carriage are the electrode reel and operator's controls. The carriage is self-propelled at any desired welding speed on a trackway built integral with the air clamp frame.

With this apparatus an oil-tight, reenforced butt weld can be made on 5/16-in. steel at a rate of 20 ft. per hr. without beveling or otherwise preparing the edges. This type of weld is reenforced on both sides; it also must pass rigid inspections for appearance as well as for strength and density, and for these reasons is often made in two or more passes. Such a weld can not be duplicated by an expert manual welder at a speed greater than 6 ft. per hr., using commercial electrodes. It is thus evident that the use of the automatic welder in this case results in a time saving of about 70 per cent. On lighter plates this saving would be still greater.

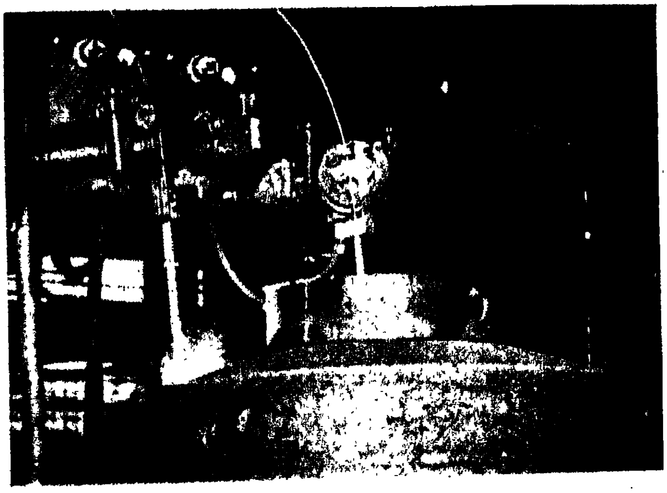


Fig. 4. Welding end plates in a circuit-breaker tank showing two automatic heads in operation.

A method for welding bottoms in cylindrical circuit-breaker tanks is illustrated in Fig. 4. The shell is centered on a turntable flush with the floor level and is rotated under the arcs held by two automatic heads. In this way the bottom of a 42-in. diameter tank with a 5/8-in. wall thickness is welded in 18 min. by a single operator as compared with the 2½ hr. required by a manual welder to complete the job.

With the recent advent of electrical machinery frames fabricated from structural members and plates welded together, automatic welding received another impetus. A machine especially developed to weld short, straight seams such as would be encountered in this type of work is shown in Fig. 5. In this device the welding head is mounted on an arm which reciprocates along the joint at welding speed. The wire reel and operator's control are mounted on the base of the machine so that the entire unit may be moved to a heavy piece of work within the radius of the supply cable reach.

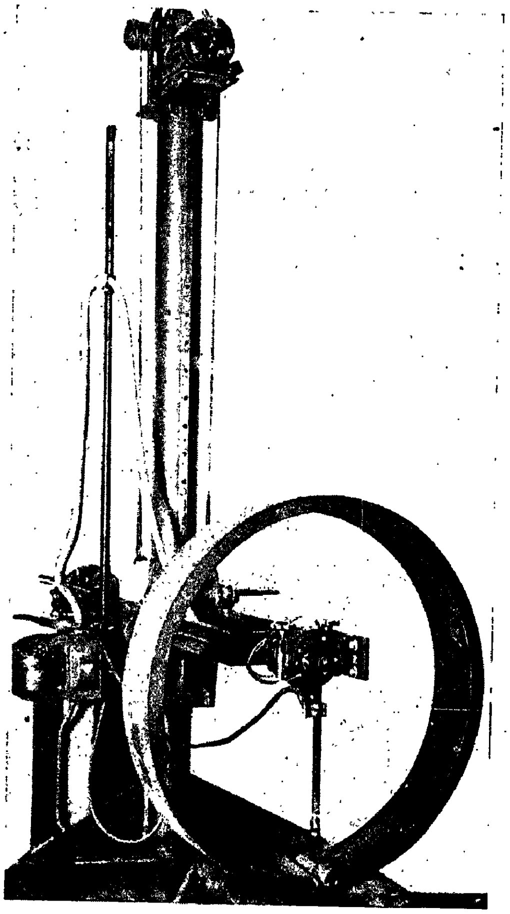


Fig. 5. Machine for making short, straight welds. A structural-steel motor frame may be seen, set up for processing

For heavy fillet welding it is necessary to tilt the work to obtain the most satisfactory results. This is especially true of plates greater than 5/16 in. in thickness for a full-strength fillet. A machine designed to accomplish this purpose is shown in Fig. 6. Tilting the work in this way permits maximum welding current and metal deposits and results in a normal fillet similar to that produced by an expert hand welder with proper manipulation.

Automatic welding is not by any means limited to heavy welds or large joints. As a matter of fact, the time saving over manual welding is much greater on thin sheets and small beads. With a special machine designed for this service certain welding operations now are performed in 45 sec. which required 7 min. for manual welding. In this case, the welding speed was 140 ft. per hr. However, a speed of 200 ft. per hr. could easily be obtained with increased welding current, but would result in a slight sacrifice in appearance.

Another interesting application of automatic welding is in connection with the manufacture of textile motors. The service requirements of these motors demand extraordinary strength and sturdiness for protection against vibration and uneven torque load. As may be seen in Fig. 7, the stator punchings and end-rings for the bracket fits are made integral by welding four angle plates across from one end-ring to the other with a fillet weld at each plate edge. These eight welds are made while the parts are held together in a jig after removal from the assembly press. As a result both the punchings and end-rings are individually welded

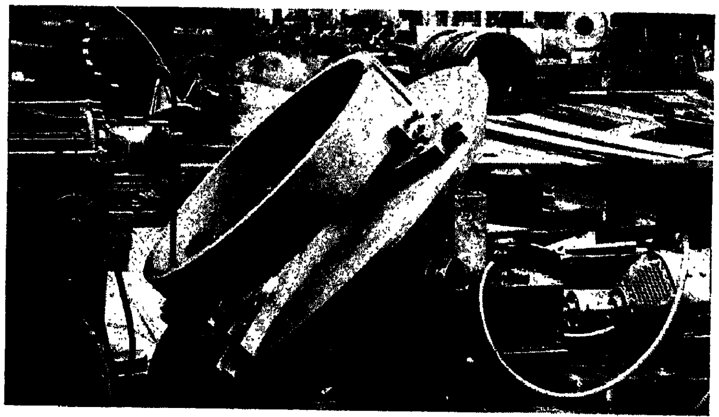


Fig. 6. Machine used in tilting heavy pieces for fillet welding

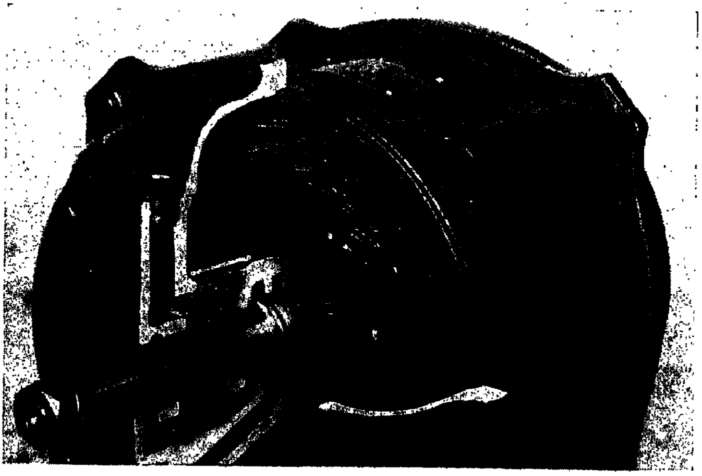


Fig. 7. Section of textile motor assembled by automatic welding. Note that laminations and end rings are held together by fillet-welded angle plates

to the angle plates and are held together under assembly pressure.

The saving in welding time affected in each of the applications illustrated give a good indication of the possibilities of the automatic-welding head in leading the way to new production economies. Provided apparatus is included to limit the handling time in changing the work, and provided such apparatus can be installed at reasonable expense, nearly every production welding job from an economical point of view, is open to automatic welding. In some applications, handling time is unavoidably the bulk of the welding time; in such cases, automatic welding can still be considered advantageous on account of its improved and consistent results.

Percentage-Differential Transformer Protection

Three-winding transformers present difficult problems for the protection engineer. Differential relays which operate on the phase difference between the currents in the different windings are particularly adapted to meet the requirements.

By R. E. Cordray

General Electric Company
Philadelphia

PROTECTION of three-winding transformers became a problem for serious consideration shortly after the introduction of this type of transformer a few years ago. The special requirements of these transformers necessitated that any suitable scheme of protection in case of an internal fault must remove the transformer from all three of its associated circuits simultaneously. In addition, an external fault on any one of its associate circuits must be cleared without putting the transformer out of service. Differential relays which operate on the phase difference between the currents in the different windings are particularly adapted to meet these requirements.

Occurrence of an internal fault in a three-winding power transformer requires the complete isolation of the transformer in the shortest possible time. In addition to this requirement, the protection must carefully discriminate between internal and external faults such as those occurring on associated transmission lines. It would be desirable of course to have the protection sufficiently sensitive so that it would function on the least possible fault; as for example, one between adjacent turns. Among other factors which affect the sensitivity are possible false operation and economy of winding replacement. However, assuming that the protective relays would operate instantaneously even a turn-to-turn fault would probably damage several turns or even a whole section of the winding before the circuit breakers could open.

Probability of a ground fault inside a transformer—that is, a fault between the winding and the core—is becoming more remote as the design of transformers continues to improve. A feature of one modern design for medium and high voltages is the complete covering of the iron core with a cylinder of very heavy insulating material, and the separation of the different voltage windings by similar insulation. For the same reason faults between phases are also becoming scarcer. Consequently, the problem consists principally of protecting against faults between turns or parts of the same winding.

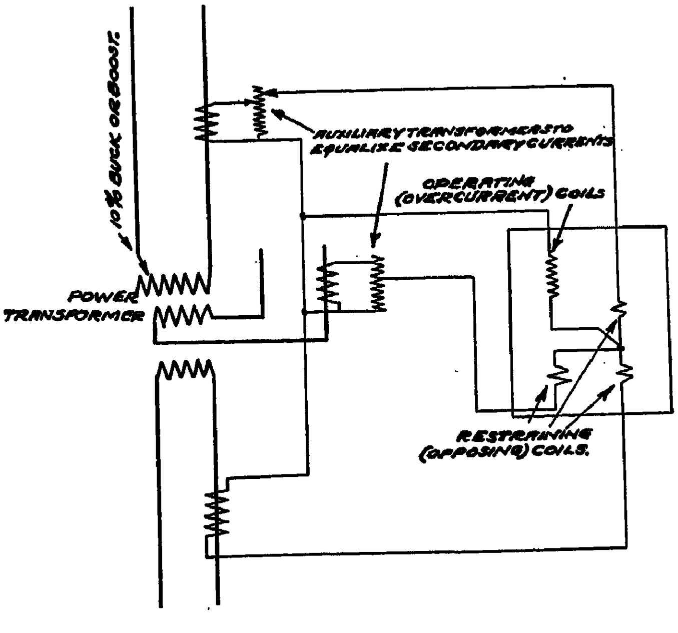

± 10% BUCK OR BOOST.
AUXILIARY TRANSFORMERS TO EQUALIZE SECONDARY CURRENTS
OPERATING (OVERCURRENT) COILS
POWER TRANSFORMER
RESTRAINING (OPPOSING) COILS.

Fig. 1. Schematic single-phase diagram for percentage differential relay

---

From a paper informally presented at the A. I. E. E. Southern District meeting, Louisville, Ky., Nov. 19-22, 1930.

PERCENTAGE DIFFERENTIAL PROTECTION

Differential protection of three-winding power transformers, as mentioned in the beginning, operates on the vector difference of the currents flowing in and out of the transformer. This protection is theoretically free from the effect of external faults, because, neglecting the exciting current, the vector difference between these currents is zero except at the time of an internal fault.

Practical application of this theory has been accomplished by connecting in parallel the secondary windings of all the current transformers in each phase, providing their ratios are such as to exactly compensate for the different voltage ratios of the power-transformer windings. In practise, such differences as do exist are easily compensated for by using auxiliary autotransformers in the current-transformer secondary circuits.

Unfortunately current transformers do not in general maintain the same ratio characteristics up to many times their full-load rating. This performance characteristic is aggravated by the current transformers being generally of different types, with one set frequently of the bushing type. This difficulty is overcome by using the percentage differential principle.

Percentage differential characteristics are in effect an automatic means of raising the setting of the relay at the time of a through fault. This automatic raising is obtained by having elements in the relay energized by the through currents; that is, by the current in each of the power-transformer windings. These elements act to oppose the torque of the operating element actuated by the "difference" current. By proportioning the number of turns in these windings it is possible to secure relay operating characteristics having any percentage desired.

Connections required for a typical relay installation of this type are shown in schematic form in Fig. 1. The relay shown here provides a separate restraining torque from each of the three power-transformer windings. Current values for torques so proportioned that the operating-coil current is 25 per cent of the average restraining or through current are shown in Fig. 2. In actual practise this proportion is set sometimes as high as 50 per cent.

A great advantage of this percentage characteristic is that it can be used on power transformers with voltage taps, even where taps are automatically adjusted to meet load conditions. In Fig. 2 is shown the "difference" current which exists when the bank has 10 per cent buck or boost taps in addition to the 25 per cent differential relay characterics. The protection afforded the power transformer is practically the same regardless of whether taps are at the zero, maximum buck, or maximum boost position.

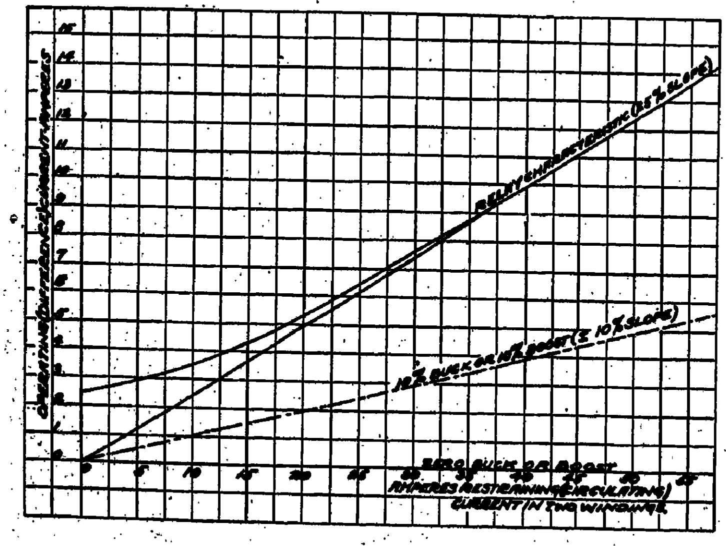


Fig. 2. Relay characteristics for 25 per cent differential protection

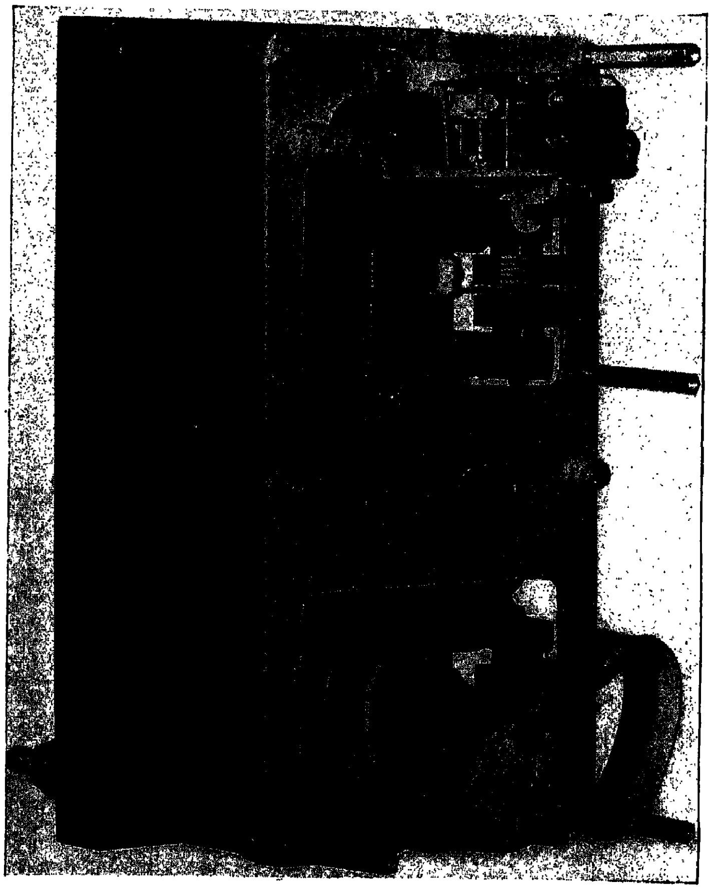


Fig. 3. Front view of differential relay with cover removed

EFFECT OF MAGNETIZING CURRENT INRUSH

Control springs for adjusting the minimum operating current are provided on these relays and are similar to those found on induction-type overcurrent relays. Minimum-current settings are determined by the probable inrush of magnetizing current to the transformer. In general, the magnetizing current is of the order of only 5 per cent of full-load current; but at the instant of energization, an inrush of transient magnetizing current generally results.

Calculations and actual tests show that the peak of this inrush of magnetizing current can be as much as eight to eleven times the full-load current rating of the power transformer (about 200 times the normal exciting current) and that this current may remain *greater* than full-load value for a relatively long time—30 to 60 cycles on a 60-cycle system.

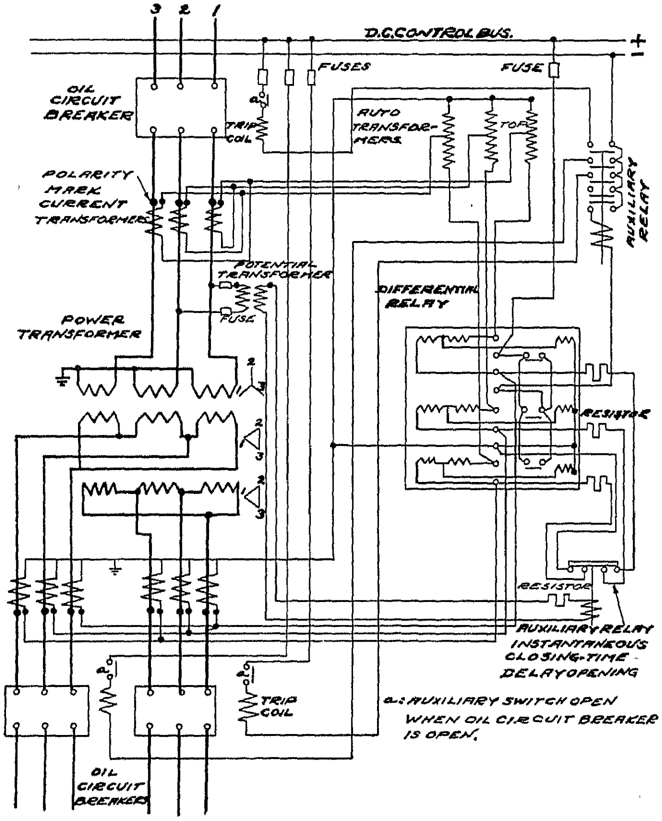


Fig. 4. Complete wiring diagram for percentage differential protection; note potential transformer and auxiliary relay for raising main relay setting during magnetizing current inrush

Relatively high current settings therefore are required to prevent relay operation during these magnetizing transients. One plan of solving this difficulty consists of using an additional relay to momentarily raise the differential-relay setting to a higher value when the power transformer bank is first energized. This relay is operated from a potential transformer placed across any one of the power-transformer windings inside the oil circuit breaker connections. While the power transformer bank is de-energized, the voltage-relay contacts connect a resistor in parallel with the operating coils of the differential relay, thereby raising their current setting. When the transformer is energized, the voltage relay operates after a predetermined time delay, thereby disconnecting the parallel resistor from the differential relay after the cessation of the magnetizing-current transient.

A complete wiring diagram for a typical percentage differential relay installation is shown in Fig. 4. This diagram shows also the connections for the voltage relay just described.

Automatic Speed Regulation

Automatic regulators to be suitable for industrial use must be quick in response, sturdy in construction, require a minimum of maintenance, and be adaptable to a wide variety of applications. How one of the newer types of carbon-pile regulators meets these exacting requirements is outlined in some detail.

By J. H. Ashbaugh

Associate A. I. E. E.

Westinghouse Elec. & Mfg. Co.
East Pittsburgh

ACCURATE speed control constitutes one of the biggest problems confronting the regulator engineer and one of the most important phases of regulation in industry. It is important because every progressive industry is striving to improve its products and to reduce manufacturing costs.

The increasing use of individual motor drives has done much to improve quality, increase production, and reduce costs. However, this same trend has made regulation a more important problem because in many processes the individual motors must be closely and accurately controlled.

Certain applications, such as galvanizing machines, continuous rod and strip mills, and sectional paper-machine drives, require practical synchronization of several motors, and at the same time necessitate a wide speed range. These conditions demand the use of d-c. motors which generally operate from a variable-voltage supply with individual regulation for maintaining a

---

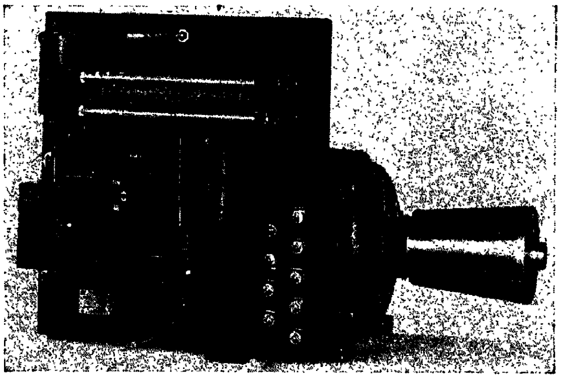
From "Automatic Regulators in Industries," (No. 31-36) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

synchronized, but adjustable, relation between motors. Speed regulation of d-c. motors to make their characteristics simulate those of synchronous machines, even under highly fluctuating load conditions, now is an accomplished fact.

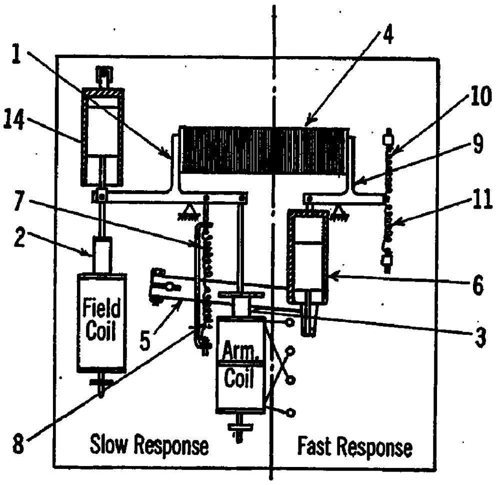
Carbon-pile regulators for this service are extremely simple and exceedingly sturdy. They are capable of field forcing or over-regulation, have effective anti-hunting characteristics, and use no contacts in the controlled circuit.

One of the newer types of carbon-pile regulators is shown in the accompanying illustrations, and may be seen to consist essentially of an electrical unit and a mechanical unit. The mechanical unit is merely a differential, consisting of a worm and nut, a clutch, and a lever system. The unit is made integral with a small synchronous motor which has a hollow shaft through which passes an internal shaft, one end of which drives the differential nut through the friction clutch, the other end being attached to a cone pulley. With the regulator motor driving the worm and the regulated motor driving the cone through a belt, any angular displacement occurring between the two is transmitted directly to the electrical unit which acts immediately to correct the undesired change in the regulated motor.

Characteristics of the electrical unit are such that should the aforementioned angular displacement occur rapidly, the electrical element will respond quickly; but if the change is slow, the correction will be correspondingly slow. As may be seen from the accompanying sketch, the pressure applied to the carbon-pile is varied by the differential lever (5) through the dash-pot (6) and two springs (7-8). The carbon-pile, of course, is connected in the field circuit of the motor to be regulated; two coils are connected to lever (1); coil (2) is in series with the field of the motor, and coil (3) is energized from the interpole. These coils stabilize the regulator and prevent hunting.



Front view of carbon-pile speed regulator for a d-c. motor



Schematic diagram of carbon-pile regulator showing mechanical parts

When a large angular displacement occurs lever (5) moves rapidly, transmitting power momentarily through dash-pot (6) to vary the pressure on the carbon-pile (4). The two springs (10-11) gradually return the dash-pot and lever to a neutral position. The sudden change in field and armature strength causes coils (2-3) to move in such a direction as to anticipate the return to normal conditions; they exert a force on the other end of the pile by deflecting springs (7-8). Dash-pot (14) merely stabilizes the lever and coil inertia. When a slow, angular deflection takes place dash-pot (6) is not moved because the air in it seeps out through an adjustable vent hole. Lever (1) is deflected by varying springs (7-8), resulting in suitable change in pressure on the carbon pile.

This regulator gives a d-c. motor the same characteristics as a synchronous motor. In actual service on a 150-hp. 900-r. p. m. motor the device completely restored and stabilized the speed within three seconds after the instantaneous application of 100 per cent load on the motor.

Considering the broader aspects of the subject, regulators may be divided into three classes; mechanical, hydraulic, and electrical. The progress of development has been in the order named, but because of the flexibility of electrical regulators they soon greatly predominated. In order to prevent surging of the quantity regulated an electrical regulator of course must have incorporated in it the same fundamentals (although in a different form) as the mechanical or hydraulic regulators. This involves careful consideration of the inertia of the system to be regulated and the precision of regulation desired.

In addition to industrial speed regulation, it is possible to effect the close automatic regulation of voltage, load, power factor, pressure, temperature, and many other quantities of importance to the modern industrial concern.

The future of regulators appears to depend largely upon the electron tube. This device is in its infancy but is thought to offer great possibilities in the elimination of moving parts and through its greater sensitivity.

Interchange of Industrial Power for Better Operating Efficiency

Large industrial establishments usually are interconnected with electric utility systems for the purchase of power; but free interchange of electric power between the two is not nearly so common as the economies involved would substantiate. The author recommends unrestricted interchange for the best economy in both systems.

By
*W. B. Skinkle**

Engineer, Pittsburgh District Power Committee,
Subsidiary Companies U. S. Steel Corporation

FREE INTERCHANGE of electric power between large industrial establishments and electric utility systems offers attractive economies to both parties in spite of inhibitions to the contrary. Interconnections are common, of course, between industrials and utilities, but usually the contracts covering such interconnections are narrow and rigid rather than flexible, and usually provide definitely for (1) the utility to furnish all the power; (2) the utility to furnish a certain stipulated base load; or (3) the utility to furnish stipulated peak power and emergency energy. However, numerous engineering analyses and an increasing amount of practical operating experience show that the greatest economies to both parties are realized through unrestricted interchange of power wherever the industrial has large quantities of either by-product or very low-priced fuel available in a form that is not economical to store.

The possibilities of power interchange between utilities and industrials open up a vast field of industrial economics; however, because of an almost unlimited number of special conditions which surround and limit each point of connection, and because industrial conditions are subject to radical and almost momentary change, too often these opportunities for power interchange are given up as impossible because of their involvement. True, such changing conditions do introduce a handicap to the drafting of sufficiently flexible contract agreements, but if both contracting parties will recognize the critical and essential fact that both parties must benefit financially from an interchange agreement, many common difficulties practically dissolve themselves. An interchange agreement should be sufficiently flexible to permit the industrial to draw power from the utility as required and deliver power to the utility whenever a surplus of low-priced fuel is available.

It naturally follows, of course, that the prices for the various kinds of power interchange should be fixed at a rate that will permit any of the classifications of power to be profitably sold by one party, and profitably purchased and absorbed by the system of the other party. Analyses of the interchange problem show that five different classifications of power may be involved in any interchange agreement between a utility and an industrial:

1. Firm power sold by the utility at any time and in any quantity up to the limit of either the contract or the equipment.
2. Surplus power available from either system by reason of surplus generating capacity, idle and awaiting growth of the system on which it is installed.
3. Off-peak dump power.
4. On-peak dump power. Dump power of either classification is power available in the industrial system by reason of surplus by-product heat or fuel which does not lend itself to practical or economical storage.
5. Lastly and most important, the emergency power available from either system to the other on short notice in case of sudden and unforseen operating emergencies.

All of these different classes of power have radically different costs to the producer and radically different values to the purchaser. A mutually acceptable determination of these factors is not extremely difficult to arrive at, and certainly forms a sound basis on which to write a mutually profitable interchange contract.

From the standpoint of the industrial establishment having available an appreciable quantity of heat energy or by-product fuel which is lost unless converted into electric energy and dumped onto the utility system, the conversion of this into electric power is accepted as the logical step. This presupposes the installation of generating equipment capable of absorbing the by-product energy and capable also of carrying some portion of the plant load. In the course of normal operation it is but natural that plant electric power requirements and plant production of by-product heat or fuel may be anything but well synchronized, with the result that at one time there will be more plant-generated power available than can be used, while at another time the power demand will exceed the plant generating capacity. Operating records are available to bear witness to the fact that these irregularities between power production and power demand can economically be smoothed out by interchange interconnection with an operating electrical utility. On the basis that boilers and turbines are already in operation and that their fixed costs and heat losses are already being absorbed by the industrial, the additional cost to the industrial for an increment of load added to the already existing plant load will be in the neighborhood of 0.4 mill per kw.-hr. for the average modern 15,000-kw. turbine-generator unit.

---

*Specially written for ELECTRICAL ENGINEERING; based upon and prepared from a discussion presented by the author at the joint A. I. E. E.-A. I. & S. E. E., meeting at Pittsburgh, March 13, 1931. Published by special permission of the Association of Iron & Steel Electrical Engineers, Empire Building, Pittsburgh. All rights reserved.

To the electric utility an interconnection with a large industrial establishment is attractive because of the possibilities in load development. Extending a mere interconnection into a full interchange may have features equally attractive to the utility and to the industrial. The utility, like the industrial, is faced with the necessity of having available more generating capacity than required to meet average load conditions, and thus may have available "surplus" power of its own. However, in view of its different basis of operation including the fact that it must use new fuel for each increment of power output, its actual cost per kw-hr. (delivered at the point of interconnection with the utility) is necessarily higher than the cost of the above mentioned industrial dump power. This is particularly true when transmission, distribution, and apparatus losses are taken into consideration. These features combine often to make it possible for the utility to purchase advantageously dump power from the industrial, even to the extent of reducing the output on its own existing equipment.

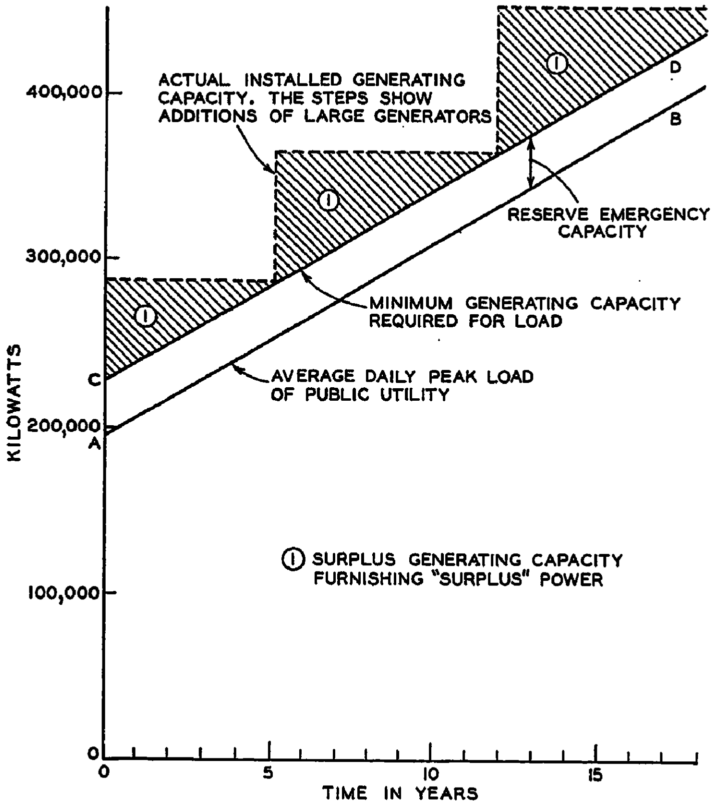


Fig. 1. Diagram indicating common method of caring for load growth in a utility system which must depend solely upon its own plants for increased generating capacity

Another economic angle to the situation, attractive and of importance to both the utility and the industrial, is that through the free interchange of power between the two systems the additions of generating capacity to each system may be "staggered," each making mutually advantageous use of the combined generating capacities of the two systems. This is perhaps one of the most important features involved in the whole interconnection interchange problem and perhaps may be better explained by centering the discussion around the two accompanying illustrations. These illustrations also will help to demonstrate the relative values of the different classes of power previously mentioned as being involved in an interchange interconnection between an industrial establishment and a utility system.

In Fig. 1 the line *A B* represents the constantly-increasing daily peak-load average during the normal growth of a public utility system. When such a system has no major power interchange interconnection, and must care for its own growth with increases in its own generating capacity, a normal margin of safety such as that represented by the vertical distance between the line *A B* and the line *C D* must be maintained. Thus the line *C D* represents the constantly increasing minimum of generating capacity that must be maintained for system operating safety. In the interests of operating efficiency and investment economy, increments in generating capacity must be made in relatively large units, such as those indicated by the projection above the line *C D*.

The capacity shown by the vertical distance between the line *C D* and the dotted lines representing the upper margin of the added capacity blocks represents "surplus generating capacity" held idle and in reserve waiting for system growth. The investment in this surplus capacity must be made *in advance* of the requirements of the system for *any part of its output*, and the fixed charges on this investment must be absorbed by the system as a whole.

When two systems make an interconnection for the purpose of interchanging energy and sharing the beneficial results of such an interchange, the combined operations can best be explained by the aid of Fig. 2, in which the upper section represents the operations of the electric utility and the lower section the operations of the interconnected industrial establishment. The sloping line *C D* represents the minimum safe generating capacity as in Fig. 1. Superimposed on line *C D* are the blocks enclosed by dotted lines representing the normal additions in generating capacity that were shown in Fig. 1. The sloping line *E F* in the lower section represents the same values for the industrial establishment. An hypothetical set of additions to generating capacity on the industrial system are shown in the steps on sloping line *E F*.

A typical normal set of operating conditions that might obtain at the beginning of operation of an interchange agreement may well be assumed to be as shown in Fig. 2. Both companies have power from surplus generating capacity available for sale. Because the electric-utility system does not *need* additional energy the industrial takes advantage of contract clauses permitting the sale of low-priced dump energy, and delivers that kind of energy to the utility system. With the growth of the industrial load its surplus generating capacity gradually is used up and at point 2 the industrial load has grown to a value that requires additional generating capacity; however because of the relatively small capacity required it is more economical to arrange for power purchase from the utility, and by so doing delay an investment in additional generating capacity until a definite load for the reserve unit has been developed.

Because of "minimum clauses" probable in such a power interchange contract, an actual purchase up to the amount of the specified minimum takes place and the industrial buys a small block of power thereby shutting down its most inefficient unit. At point 3 the utility reserve has decreased, as a result of its own load growth, to a point which requires that the industrial again pick up its load. Because of the economy of large units the industrial installs more capacity than is immediately required, and again takes advantage of the low-priced dump-energy clauses to deliver power to the utility system earning at least the fixed charges on its investment in surplus generating capacity, which otherwise would be idle and non-productive between points three and four. At point four the utility has used up its own reserve and is in the market for the purchase of surplus capacity which in this case can now be furnished by the industrial establishment until such time as point five is reached. At that time the utility must have additional generating capacity available for operation, and the first cycle has been completed. These cycles may be repeated indefinitely, the actual span of years per cycle depending upon conditions prevailing.

Fig. 2 indicates that during periods 1-2, 3-4, 5-6, 7-9, and beyond 10, the industrial profits by the sale of dump power and the utility profits by the purchase of that very cheap power. Some power is supplied to the electric utility by the industrial from its own surplus generating capacity during the periods from 4 to 5 and from 9 to 10. During periods 2-3 and 6-7, the industrial has purchased base-load power from the utility. The utility has sold some power from equipment that otherwise would have been idle, and thus has helped to carry the fixed charges on the otherwise idle equipment, and also has been able to delay the large investment in new generating capacity for the periods of time represented by the time increment between point 4 and point 5, and between points 8 and 10. A parallel situation has been comparably remunerative to the industrial establishment. A utility investment in additional generating capacity may easily reach $6,000,000, which if delayed for even one year means a saving of some $780,000 in fixed charges. Large industrial establishments may spend as much as $2,000,000 on power plant equipment; hence the fixed charges on that investment will amount to $260,000 per year, and that investment probably can be delayed for a relatively longer time than the corresponding utility investment. These savings represent some of the fruits of power interchange between the two systems.

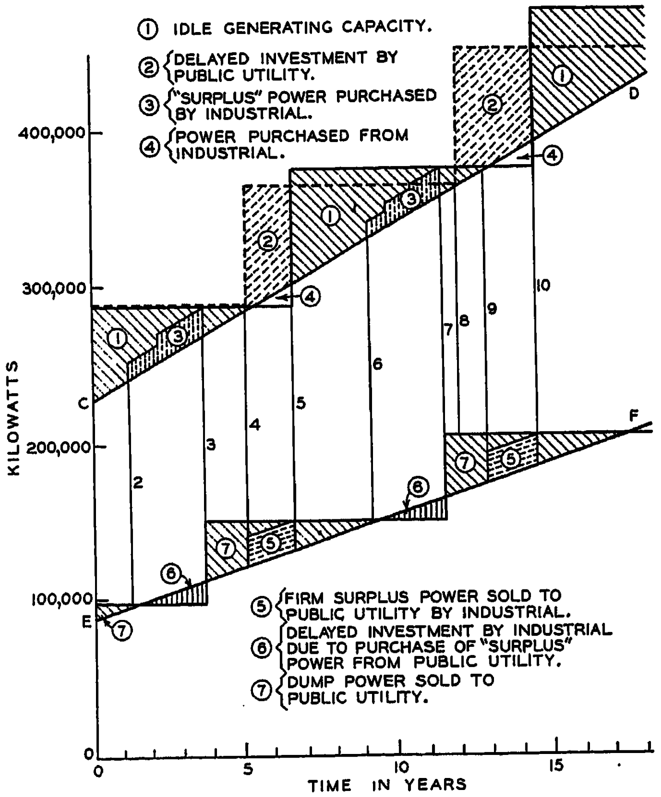
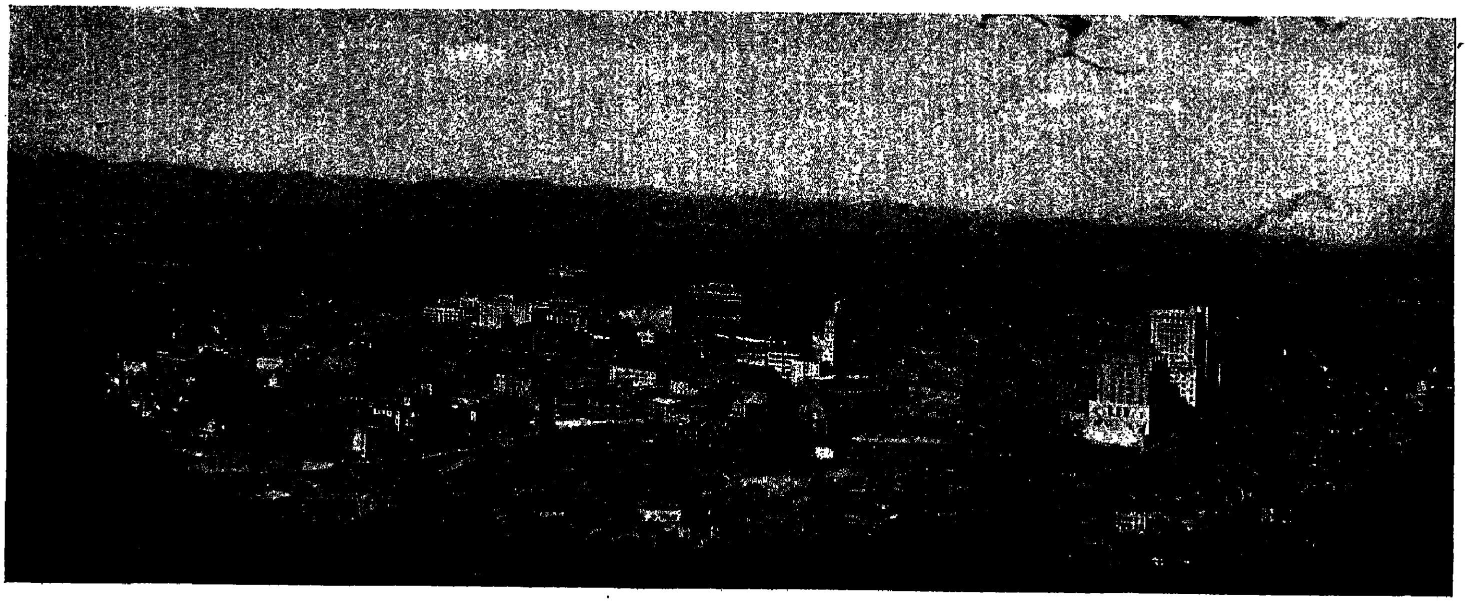


Fig. 2. Diagram showing interlocking development of interconnected utility and industrial systems where mutual use is made of total generating capacity of combined systems

In this brief sketch the attempt has been to outline some of the important advantages to both parties that may result from a free interchange of electric energy between the system of a large industrial establishment and an electric utility system, particularly where the industrial establishment has the characteristics of some of the large steel mills. It is of sufficient importance to warrant its being emphasized again, however, that an interconnection or an interchange contract between a utility and an industrial system must provide for definite profit to both parties if such a contract is to endure.

News
Of Institute and Related Activities



Asheville, N. C., as it appears from the slopes of nearby Beaucatcher Mountain

Summer Convention Program Announced

Offers Timely Technical Topics Attractively Seasoned With Recreation Features 'Midst Scenic Splendors of the Old South

ASHEVILLE, North Carolina, will be host to the 1931 A. I. E. E. summer convention which will be held June 22-26, with headquarters at the Grove Park Inn. An exceptional program combining the annual business meeting, technical sessions, entertainment, and sports, with ample opportunity to see some of the splendor of the mountains surrounding Asheville, has been arranged by the general convention committee. Excellent concrete highways lead from the city in all directions and wind their way over the various mountain ranges to such points of scenic interest as Chimney Rock, Lake Lure, Mount Pisgah, and the Pisgah National Forest and Game Reserve.

TECHNICAL AND BUSINESS SESSIONS

A selection of specially excellent papers from a wealth of material comprises a technical program of broad scope and current interest. Symposiums comprise three of the sessions; one on the important subject of system interconnections; another on the interesting topic of communication systems for electric utilities; a third dealing with the history of electrical units, the volt, the ampere and the ohm. Four other sessions will present papers describing the latest developments in the fields of power cables, automatic stations, electrical machinery, and research. Annual reports of the Institute's technical committees, reviewing the advances made in theory and practise during the past year, will be available at one of the sessions. A tentative list of the papers for each of these sessions is given in the accompanying tentative program.

The business side of the convention will include the annual meeting of the Institute, a report of the tellers' committee covering election of officers for 1931-1932, the president's address and presentation of prizes for papers. The Lamme Medal, awarded several months ago, will be presented to Dr. William J. Foster, Schenectady, N. Y., "for his contributions to the design of rotating alternating-current machinery."

ENTERTAINMENT AND SPORTS

Asheville long has been noted for its wonderful climate and the natural beauty of the surrounding country. Attractive trips have been arranged each day for the ladies attending the convention, with luncheons at noted resorts; several bridge games will be arranged.

The president's reception, followed by dancing, will be held on the first night of the convention, Monday, June 22, at the Grove Park Inn. An informal get-together dinner followed by dancing will be held at the George Vanderbilt Hotel Tuesday evening, June 23. Attractive entertainment features will be provided at this dinner. The convention banquet will be held at the Grove Park Inn Wednesday evening, June 24, also to be followed by dancing.

Facilities of the Biltmore Forest and the Asheville country clubs will be at the disposal of those attending. The customary golf and tennis tournaments for the Mershon Cups will be held. The golf courses at Biltmore Forest and

Asheville country clubs will be at their best in June and are sure to prove attractive to golfers and near-golfers.

Both of these clubs also afford fine tennis courts.

Notice of A. I. E. E. ANNUAL MEETING

The Annual Meeting of the American Institute of Electrical Engineers will be held in the Grove Park Inn, at Asheville, N. C. at 10 a. m. on Monday, June 22, 1931. This will constitute one session of the annual summer convention, which is to be held in Asheville June 22-26.

At this meeting the annual report of the board of directors, and the report of the committee of tellers concerning the ballots cast for the recent election of officers will be presented.

Such other business, if any, as properly may come before an annual business meeting may be considered.

(Signed) F. L. HUTCHINSON,
National Secretary.

OUTLINE OF PROGRAM

(Eastern Standard Time throughout)

MONDAY, JUNE 22

9:00 a. m.	Registration
10:00 a. m.	Annual business meeting of the Institute Address of welcome by the mayor of Asheville Annual report of the board of directors (in abstract) by F. L. Hutchinson, national secretary Report of tellers committee on election of officers; introduction of and response from president-elect. Presentation of prizes for papers Presidential address, by W. S. Lee Lamme Medal presentation
2:00 p. m.	Conference of officers, delegates, and members Qualifying round for Mershon trophy, at Biltmore Forest Country Club Tennis at Asheville Country Club
2:30 p. m.	Ladies' drive about city followed by tea at Mountain Meadows
9:00 p. m.	President's reception—dancing—at Grove Park Inn

TUESDAY, JUNE 23

9:00 a. m.	Registration
9:30 a. m.	Two technical sessions— (a) Symposium on communication services for electric utilities (b) Electrical machinery
1:00 p. m.	Ladies' luncheon and bridge, at Biltmore Forest Country Club
2:00 p. m.	Conference of officers, delegates, and members (continued) Sports as scheduled
7:00 p. m.	Get-together dinner, at George Vanderbilt Hotel

WEDNESDAY, JUNE 24

9:30 a. m.	Two technical sessions— (c) Symposium on interconnections (d) Symposium on electrical units
12:30 p. m.	Directors' luncheon and meeting, at Grove Park Inn
2:00 p. m.	Trip to Biltmore house and estate Sports as scheduled
7:00 p. m.	Convention banquet, at Grove Park Inn

THURSDAY, JUNE 25

9:30 a. m.	Two technical sessions— (e) Automatic stations (f) Cables Semi-finals in golf and tennis
2:00 p. m.	Technical session— (g) Research, selected subjects, technical committee reports Finals in golf and tennis
2:30 p. m.	Drive to Chimney Rock and Lake Lure for tea

FRIDAY, JUNE 26

All-day excursions, choice of:

(1) Carolina Power and Light Company's Waterville plant

(2) Champion Fibre Company and American Enka Corp.

(3) Mount Pisgah

LADIES PROGRAM

MONDAY, JUNE 22

10:00 a. m.	Opening of convention President's Address, by W. S. Lee
2:30 p. m.	Drive about city followed by tea at Mountain Meadows
9:00 p. m.	President's reception—dancing, at Grove Park Inn

TUESDAY, JUNE 23

1:00 p. m.	Ladies' luncheon and bridge at Biltmore Forest Country Club
7:00 p. m.	Get-together dinner at George Vanderbilt Hotel

Waterville 135,000-kva. hydroelectric plant of the Carolina Power & Light Company

Wednesday, June 24

2:00 p. m. Trip to Biltmore house and estate

7:00 p. m. Convention banquet, at Grove Park Inn

Thursday, June 25

2:30 p. m. Drive to Chimney Rock and Lake Lure for tea

Friday, June 26

All-day excursions, choice of trips as scheduled

Trips

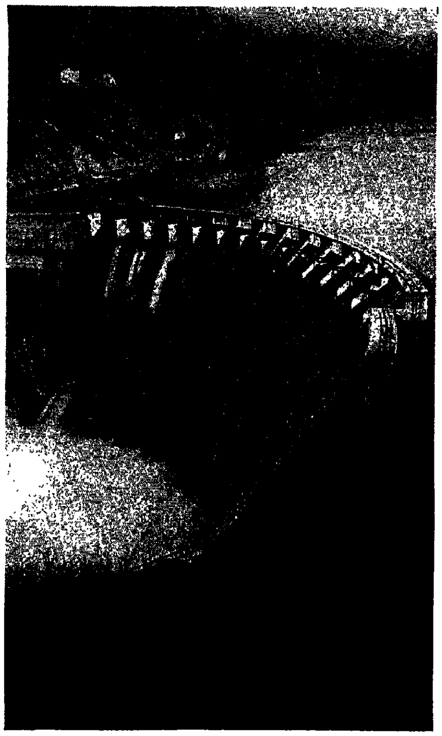
Friday, June 26, will be devoted to an all-day excursion with a choice of one of the following trips: Carolina Power and Light Company, Waterville plant; Champion Fibre Company and American Enka Corp.; Mount Pisgah.

The Waterville plant of the Carolina Power and Light Company is situated on the Big Pigeon River close to the Tennessee state line. Twelve miles upstream a concrete arch dam, 200 ft. high and about 700 ft. long at the top, forms a reservoir from which water is conducted to the plant through a concrete-lined tunnel approximately 33,000 ft. in length. Construction is in two sections known as the upper and lower levels, connected by a vertical circular section known as the gap shaft. The power house contains three 45,000-kva., 13.8-kv., 400-r. p. m. vertical generator units each directly connected to a 55,000-hp. Francis type waterwheel. The unit system is employed and each generator is connected directly to the step-up bank of transformers without low-voltage oil circuit breakers.

Through the Waterville high-voltage bus an interconnection is formed which establishes a complete connection between the Great Lakes and the Gulf of Mexico. Transmission lines interconnect with the Appalachian Electric Power Company to the North, the Tennessee Public Service Company and Tennessee Electric Power Company to the West, and the Duke Power Company to the South, as well as supplying the Carolina Power and Light Company's load in western North Carolina.

The large Canton, N. C., plant of the Champion Fibre Company is unique in the history of industrial development in that it serves the paper industry as well as the tanning industry. When chestnut wood is employed as the raw material to produce soda pulp the tannin must first be extracted. The tannin extract unit for this purpose has a capacity of 500 barrels of liquid tannin extract per day. Sulphate pulp is produced in large quantities from the hemlock and spruce. Another mill produces high-grade book, bond, tablet, and envelope papers and has a daily capacity of 100 tons. Chlorine used for the bleaching of pulp is produced by an electrolytic plant having a capacity of 70 tons daily. The chief by-products of this industry consists of highly volatile methyl compounds, turpentine, and sodium resinate, obtained from the cooking of pine wood for sulphate pulp.

Mount Pisgah, with an altitude of 5,749 ft. is the principal high point in the Pisgah National Forest and Game Preserve. Its summit affords a panorama view of Buncombe, Transylvania, Henderson, and Haywood counties, overlooking Little Bald, Big Bald, Cold Mountain, and Eagles Nest. The beautiful mountain laurel and rhododendron also will be in bloom during June. This excursion consists of approximately a 60-mile round trip. Delightful meals and hotel accommodations may be secured at the famous Pisgah Forest Inn, near the top of the mountain.



Waterville dam of the Carolina Power & Light Company

Railroad Rates

It has been ascertained that in nearly all cases the summer tourist rates are lower than those offered by the convention certificate plan. On this account certificate rates are not being arranged and members are advised to purchase Summer Tourist tickets to Asheville, N. C.

Convention Hotel Rates

Reservations for hotel accommodations should be made by writing directly to the hotel preferred. Rates for rooms with bath are:

Hotel	Plan	Single	Double (per person)	No. of Guests
Grove Park	A	$12	$10	400
George Vanderbilt	E	3	2.50	400
Battery Park	E	3.50	3	400
The Manor	A	9	8	100

All hotels are within ten minutes' easy driving of the convention headquarters hotel.

Committees

The general convention committee for the 1931 summer convention consists of the following members, who are officers or chairmen of other committees as indicated: E. P. Coles, chairman; C. E. Waddell, honorary chairman; W. S. Rodman, vice-president; M. E. Lake, secretary-treasurer; R. R. Laxton, assistant secretary-treasurer; A. E. Knowlton, meetings and papers committee; E. S. Lee, sections committee. The following members are chairmen of subcommittees: T. F. Ball, publicity; Mrs. F. Q. Boyer, ladies; W. S. Lee, Jr., hotels and registration; W. E. Mitchell, finance; F. L. Moser, transportation and trips; J. E. Sirrine, sports; and C. E. Waddell, entertainment.

Tentative Technical Program

Tuesday—9:30 a. m.

(A)—Symposium on Communication Services for Electric Utilities

Communication Services for Electric Utilities, by C. F. Craig, American Telephone & Telegraph Company; R. N. Conwell, Public Service Electric & Gas Company; G. W. Keenan, Pennsylvania-New Jersey Interconnection; and E. C. Briggs.

Communication in the Western Division of the Niagara Hudson System, by Colonel William Kelly, Niagara Hudson Power Corporation.

Communication Facilities of a Metropolitan Power System, by P. B. Juhnke, Commonwealth Edison Company.

Communication Services for the New England Power Association, by C. A. Booker, New England Power Association; and M. E. Clark, New England Telephone and Telegraph Company.

Communication Service of the Arkansas Power and Light Company, by C. E. Stewart, Arkansas Power & Light Company.

Tuesday—9:30 a. m.

(B)—Electrical Machinery

Reestablishing Excitation of a Loaded Alternator in Parallel with Others, by D. D. Higgins and E. Wild, Commonwealth Edison Company.

The Calculation of the Constants of Synchronous Machines, by L. A. Kilgore, Westinghouse Electric & Manufacturing Company.

Determination of Synchronous Machine Constants by Test, by S. H. Wright, Westinghouse Electric & Manufacturing Company

Transient Oscillations in Distributed Windings, by L. V. Bewley, General Electric Company.

Wednesday—9:30 a. m.

(C)—Symposium on Interconnections

Interconnection Services—Their Classification and Evaluation, by A. E. Bauhan, Public Service Electric & Gas Company.

Interconnection—New England District, by E. W. Dillard and W. R. Bell, New England Power Engineering and Service Corporation.

The Pennsylvania–Ohio–West Virginia Interconnection, by H. S. Fitch, West Penn Power Company.

Interconnection Development and Operation, by G. M. Keenan, Pennsylvania-New Jersey Interconnection.

Wednesday—9:30 a. m.

(D)—Symposium on Electrical Units

International Standard of Electromotive Force and Its Low-Temperature Coefficient Form, by Marion Eppley, The Eppley Laboratory, Inc.

Design of Potentiometers, by I. Melville Stein, Leeds and Northrup Company.

Electrical Units and Their Application, by L. T. Robinson, General Electric Company.

History of the Unit of Electrical Resistance with Special Reference to Mercury Standards for the Ohm, by H. B. Brooks, National Bureau of Standards.

Thursday—9:30 a. m.

(E)—Session on Automatic Stations

Supervisory Control Systems, by O. K. Marti, American Brown Boveri Company.

Supervisory Control for A-C. Electrified Railroads, by C. P. West, Westinghouse Electric & Manufacturing Company; and H. C. Griffith, Pennsylvania Railroad Company.

Automatic Combustion Control, by C. H. Sanderson and E. B. Ricketts, New York Edison Company.

Operating Experience with Automatic Stations, by F. F. Ambuhl, Toronto Hydro-Electric System; and Garland Stamper, Columbia Engineering & Management Corporation.

Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control, by R. M. Stanley, Byllesby Engineering & Management Corporation.

Thursday—9:30 a. m.

(F)—Cables

Economics of High-Voltage Cable, by D. W. Roper, Commonwealth Edison Company.

Characteristics of Oil-Filled Cable, by G. B. Shanklin and F. H. Buller, General Electric Company.

A Complete Oil-Filled Cable System—Condenser Joints and Terminals, by R. W. Atkinson and D. M. Simmons, General Cable Corporation.

Insulation Variability—Its Influence in Determining Breakdown Voltages, by D. C. Holmes, West Virginia University.

Thursday—2:00 p. m.

(G)—Research and Selected Subjects Technical Committee Reports

Extinction of Short A-C. Arcs, by T. E. Browne, Jr., Westinghouse Electric & Manufacturing Company.

A Corona-Tube Voltage Regulator, by H. W. Dodge and C. H. Willis, Princeton University.

Residual Air and Moisture on Impregnated-Paper Insulation—III, by J. B. Whitehead and F. Hamburger, Jr., Johns Hopkins University.

The Application of the Cooperative Method of Instruction to Engineering Schools and Polytechnic Institutes, by D. C. Jackson, Jr., University of Kansas.

Arcing Faults on Transmission Systems, by J. R. Eaton, Consumers Power Company; J. K. Peck, N. E. L. A.; and J. M. Dunham, American Telephone & Telegraph Company.

C. E. Grunsky to Speak at Pacific Coast Convention

C. E. Grunsky of San Francisco, internationally known to engineering circles, and popular and well-beloved as president (second term) of the American Engineering Council, will be the feature speaker and an honor guest of the forthcoming Pacific Coast convention. Thus Mr. Grunsky will lend his rare talent to the already indisputable attractiveness of the convention's technical program, while adding the charm of his own personality to the attractive natural beauties of the Lake Tahoe region, so sure of appeal to the "tired engineer" and his family attending the Pacific Coast's "vacation convention."

August 25-28, 1931, are the dates set for the convention, carefully chosen to fit as nearly as possible the opening dates of fall school terms and to permit college students to attend without missing classes, and families to fit the convention into vacation plans without interference with the children's school activities.

D. I. Cone, chairman of the convention technical program committee, has announced that there will be four technical sessions, two student sessions, and one evening session, promising a particularly well-balanced, interesting and timely technical program. A. G. Jones, chairman of the convention entertainment committee, has reported that the proposed entertainment features include a barbecue supper, steamer rides around Lake Tahoe, several special features designed exclusively for the ladies, and participation in a colorful street show and dance put on by the resort village.

A. S. T. M. to Exhibit Testing Apparatus and Machines

For the first time in history, the American Society for Testing Materials will sponsor an exhibit of testing apparatus and machines in conjunction with its annual meeting to be held at The Stevens Hotel, Chicago, June 22-26. This exhibit, in which government, institutional, and private laboratories are expected to participate, will display equipment used in the testing of materials and products including recording, control, metallographic, optical, chemical, pyrometric and physical devices, fatigue machines, distributors, etc., exhibited by the leading companies in these fields, as well as by foreign companies covering practically every phase of the testing field. Another unique feature of the exhibit will be participation by certain of the society's committees; they have signified their intention of showing apparatus developed for special committee work, not yet commercially produced, but developed for specific tests and determinations.

A. A. A. S. and Associates Plan Week of Meetings

Launching the plan of holding annually a summer meeting of truly national character, the American Association for the Advancement of Science, together with associated societies, is planning a series of meetings, the first of which will be held in Pasadena, June 15-20 inclusive; the 1932 meeting will be in New Haven, Connecticut; the 1933 meeting in Chicago; and the 1934 meeting back to the Pacific Coast in San Francisco.

At these meetings, each group extending over the period of a full week, scientific sessions will be confined chiefly to the mornings, with the emphasis of the session on symposia; afternoons to be given over to discussion, personal contacts and excursions. Both Professor Thomas H. Morgan, (Calif. Inst. Tech.) retiring president, and Professor Franz Boas, (Columbia, Miss.) recently elected president of the association, are planning to attend the 1931 meetings.

Special round trip rates will be offered by the railroads, making the traveling expense from New York and return approximately $140.00; from Chicago, $90.00. A preliminary program giving the plans in greater detail will become available by mail as soon as sufficient information can be assembled from sections and affiliates.

Summary of Some Pittsburgh Discussions

ONLY discussion given at the meeting and submitted in writing in accordance with A. I. E. E. rules governing it is summarized; complete discussion, together with all papers so approved, will be published in the TRANSACTIONS. The titles of the papers and the names of their respective authors were published on page 140 of the Feb., 1931, issue of ELECTRICAL ENGINEERING.

Alternating-Current Low-Voltage Networks

Six papers were presented dealing with two phases of the network problem. Three of these gave attention to what might be termed the theoretical or fundamental side of the question, while the others described new installations either recently completed or under way.

Cable Burn-Off Characteristics

W. R. Bullard discussed the subject and he believed the most important conclusion was that single-conductor buried cable of the non-metallic armored type had better burn-off characteristics than the other types of construction tested. He also brought out that with the use of this type of cable the necessity for good burn-off characteristics might be eliminated.

W. A. Del Mar discussed this subject explaining that there were many types of non-metallic trench cable being manufactured and purchased on various kinds of specifications, some of which merely describe one type or another, while others are based only on performance tests. He expressed the need of coordination in this field and advocated a course of procedure whereby the devising of tests would be a joint effort of the operating and manufacturing engineers. The designs of cables to meet these tests should be left to the cable maker.

B. M. Jones discussed this subject from the economic standpoint of planning an a-c. low-voltage network with provisions for sufficient spare capacity to burn clear a fault of the most severe type in the weakest spot with any one particular supply feeder out of service.

Arcs in Low-Voltage A-C. Networks

W. R. Bullard in his discussion of this subject explained that his experience agreed with the statement in the paper presented that pre-carbonization of cable insulation destroyed its arc-extinguishing features.

W. G. Dow discussed the differences in the values of the arc-reignition characteristics brought out by the two papers and set forth reasons for the difference in the results.

T. E. Browne, Jr., discussed "The Reignition of Metallic A-C. Arcs in Air." He commented on the point that the oscillograms were the first obtained that had shown directly on a time axis just what occurs to the current and voltage of a short a-c. arc during the elusive-current zero period.

A Primary Network

E. R. Hendrickson in his discussion of the subject inquired if the primary network would represent the correct solution for service to a territory of low- or medium-load density, where because of the importance of continuity of service or future load growth, a secondary network would be required in the future.

W. R. Bullard in his discussion of the subject advocated using a type of system which would eliminate the intermediate transformation and supply the distribution transformers directly with generating station or transmission terminal substation voltage. Such a system would have the advantages of simplicity and greater economy.

H. Richter discussed the paper from the standpoint of developments made in the apparatus employed. The two 1,500-kva. transformers are the largest subway-type transformers thus far produced and the regulators so far as is known are the first of the subway type built in this country.

A. H. Sweetnam discussed the subject and the planning which lead up to the adaption of a 4,000-volt network system to supply a certain area. Estimates were made of the relative cost of supplying this area by means of a 4,000-volt network or the construction of a new substation. The economic study was extended to cover ultimate load requirements and it was found to favor the 4,000-volt network system with a saving of 20 per cent capital investment.

In contrast to the foregoing paragraph H. L. Wallau discussed a comparative estimate made five or six years ago which indicated a relative investment of 100 per cent for the radial type *vs.* from 106 to 118 per cent for the networked type.

G. M. Miller in his discussion of this subject explained that the primary network is a long step forward in a scheme to reduce investment and operating costs, to provide improved service, and give greater flexibility in handling increases in load.

The Philadelphia A-C. Network System

H. Richter discussed this system and drew attention to the length of time required for transformer secondary fuses to clear primary faults. He believed that the automatic protector would answer this requirement much better than the transformer secondary fuses.

System Grounding Problems

In the session devoted to grounding, relaying, and transmission problems five papers were presented. One of these was in reality a subcommittee report covering grounding practises.

System Grounding Problems

E. C. Stone capably analyzed the second report of the subject committee on grounding. A comparison with the first report of eight years ago indicated no radical changes but some interesting trends, one of which was toward the solidly-grounded system.

H. M. Trueblood discussed "Reactance of Transmission Lines with Ground Return" and analyzed the terms in Carson's expression on the hypothesis that the earth is of infinite conductivity.

P. A. Jeanne discussed this paper and expressed his beliefs that the method of developing the formulas for the zero sequence impedance as outlined in the appendix is preferable to the method given in the main body of the paper because it involved only the use of complete ground return circuit impedances.

C. L. Gilkeson presented a discussoin prepared by F. J. Grueter on the same paper. One of the points discussed was the simplifying assumption made in the development of the method of calculating zero-sequence impedance that uniform current exists along the length of the ground wire. This condition holds only when the ground wire is terminated in impedances to ground which are small compared to the resistance to ground of the tower footings. G. Waschick in his discussion of this paper also referred to the same point.

J. E. Clem discussed "Power System Voltages and Currents under Fault Conditions." He suggested a classification based on overvoltages for grounding systems, or circuits, as follows: solidly-grounded, effectively-grounded, non-effectively-grounded, and isolated. For this classification certain auxiliary terms were defined.

H. W. Bibber's discussion of this paper was read by J. E. Clem. For those who wished to go further into the subject in a more detailed and mathematical manner he suggested an article in the May 10, 1930, *Revue Générale d'Electricité* by J. Fallou.

C. A. Powel read Mabel Macferran's discussion on "Simultaneous Faults in Three-Phase Systems," which clearly pointed out the practical value of the paper. J. E. Clem read a discussion prepared by H. W. Bibber on this paper. It indicated that Miss Clarke's methods of calculating simultaneous faults on grounded systems could be extended to include the determination of currents and voltages in isolated neutral systems.

Closing Session Discussion

The closing session was devoted to "selected subjects" concerning industrial power applications and communication developments.

R. R. Johnson discussed "A Modern Electrified Dairy Plant" and explained that the change-over of which the authors spoke was conceived approximately six years ago. Another interesting point cited was that only five unarranged outages, totaling one hour and three minutes, have occurred since the substation was installed in 1925.

One of the interesting points described by A. T. Ruttencutter in connection with his discussion of the paper was the application of the "Electropure" process of pasteurizing milk. B. W. Faber also discussed this paper and inquired if the pasteurizing of milk increased the quality of the milk.

J. L. Woodbridge discussed "Power Supply for Telephone Systems" and described the developments in the design and application of the storage battery for this service. I. R. Smith in his discussion of this paper described and illustrated with lantern slides the development of the dry disk copper oxide or Rectox rectifiers for the various applications described in the paper. Efficiency and life test performance curves for these units were also shown.

K. C. White discussed "Power Supply for Telephone Systems." He explained that the Pennsylvania Railroad had applied several of the power plants described in the paper to a rather extensive dial telephone system in the Western Pennsylvania and the Eastern Ohio areas. These automatic power plants have greatly reduced the maintenance required resulting in a smaller operating personnel, better voltage regulation, longer battery life, and practically fool-proof operation. R. L. Dunlap in connection with the discussion of this paper described the advantages accruing from the installation of some of the 72 automatic power plants installed in the Pittsburgh territory.

C. S. Alt discussed this paper as well as "Telegraph Power Plants." He described the special requirements for emergency engine sets for this particular service, such as the ease of starting, quietness, freedom from vibration, and safety features.

In connection with discussion on "Telegraph Power Plants," G. H. Kendricks described interestingly some of the early power plants of the Western Union Service in Pittsburgh and told of some of the difficulties encountered.

OVERSEAS TELEPHONE SERVICE

J. P. Scott discussed this subject and inquired as to the total per cent of lost time due to all causes; also as to how often magnetic storms were usually experienced.

W. C. Hecht asked how the practical operating hours were affected by the differences in time of day at the terminals.

N. S. Hoff inquired as to the steps involved and the length of time required from the conception of a radio circuit to the establishment of actual service.

In other discussion on this paper W. L. Schafer referred to the gains obtained by the use of the directive antenna arrays at the transmitter and receiver, and inquired as to the possibilities of further substantial gains by such means.

Other equally interesting and pertinent questions were asked during the discussion of this paper which was presented by F. A. Cowan.

Engineers' Economic Conference To Be Held by Stevens Institute

AN ECONOMIC conference for engineers will be held from Aug. 30 through Labor Day, Sept. 7, 1931, at the engineering camp of Stevens Institute of Technology near Johnsonburg, Warren County, New Jersey. The engineering alumni of Columbia University and the alumni of Stevens, under whose joint auspices the conference will be held, will welcome to the camp graduates of other colleges and younger members of the national engineering societies. The hours for lectures, conferences, and round-table discussions by some of the leading economists and engineers of the country are to be scheduled so as to permit the men in camp to make full use of the camp's unusually good facilities for land and water sports.

The serious part of each day's program will have two main elements: in the morning the lectures and discussions will deal with "The Dollar Factor in Engineering," or "Technique in Calculations Involving Money;" at the open forum and round-table discussions in the evening, elements in depression, and seasonal and cyclical fluctuations will be considered. The Carnegie Corporation, on the recommendation of the American Association for Adult Education, has endorsed the project through a grant of $1,500.

THE ECONOMIC FACTOR IN ENGINEERING

Lectures and conferences scheduled for the morning hours will be under the direction of William Duane Ennis, head of Stevens' department of economics of engineering who will be assisted by members of the Stevens and Columbia faculties. In his outline of the subjects to be dealt with Prof. Ennis remarks that:

> Every engineer knows that a point is reached in his problem where commercial factors, so-called, must receive consideration. Too often from this point the problem is relegated to another than the engineer; perhaps to a lawyer, perhaps to a "business man." No sufficient reason for this exists. There is a body of principles underlying the evaluation of commercial factors just as there is a mass of doctrine back of engineering factors. In the setting of an interest rate, no less than in the determining of a stress, there is a mass of facts and coordinations, not scientific, perhaps, but nevertheless organized. The course proposed for the coming summer aims to develop some of the principles which are fundamental in applying money factors to engineering problems.

THE BUSINESS CYCLE

In addition to the morning series of lectures and seminars on the "money factor" in engineering, the economic conference is planned to include eight or nine evening lectures and round-table discussions on the business cycle. Four major questions of business depression are proposed for consideration:

1. What is the most significant statistical description of what has happened since the fall of 1929?
2. What statistical approach looks most hopeful for forecasting or for starting a public works program?
3. What is the most significant explanation of what has happened?
4. What to do about it.

The first two questions, bringing out a description of a period of depression, will be discussed by leading financial and government analysts. The third will be submitted to investigators in theoretical economics associated with university faculties and research staffs of private corporations. Under the fourth topic, emergency relief, industrial stabilization, unemployment insurance, and long-range planning will be debated by men who have been actively engaged in solving such problems for industrial organizations and civic committees.

Engineers interested in attending this conference should communicate promptly with Stevens Institute of Technology, Hoboken, New Jersey. Accommodations at the camp are limited.

Mining Engineers Report Upon Russian Living Conditions

AMERICAN engineers considering employment in the United States of Soviet Russia are face to face with a stern situation according to an exhaustive report presented to and approved by the board of directors of the American Institute of Mining and Metallurgical Engineers March 20, 1931. The investigation was authorized by the A. I. M. E. board of directors Nov. 21, 1930 and the report was published on pp. 207-8 of *Mining and Metallurgy* for April 1931. The following excerpts are taken from the published report:

General Observations

"The government in Russia is undertaking an experiment completely at variance with accepted American procedure by methods wholly contrary to American ideals. The country has a form of government comparable with the most drastic type of martial law as Americans understand that term. Industrial conscription forces every individual into service.

"The Soviet Government is seeking to industrialize in the next few years a backward country under a program which, if completed, will place Russian industrial production on a plane with or above the present production of the United States in the major basic industries—a plane which has been attained only by decades of orderly progress. The first step of their program is the Five-Year Plan now in course of execution. The Soviet Government proposes to accomplish its aims not through private initiative, but through direct government action. . . .

"The success of the plan is absolutely essential for the continuation of the Soviet regime and nothing—not even human life—is a barrier to their efforts to force the plan to success. A wholly artificial condition of living has been created. Individual initiative and the reward for effort are completely submerged under despotic discipline and drastic penalties. . . .

Living Conditions

"Food, generally speaking, is scarce; some, of very poor quality. It is extremely expensive unless bought at government stores with a government food card. While conditions are not uniform throughout Russia, in Moscow and Leningrad long lines of people are obliged to stand in front of these stores waiting to enter. . . .

"Individuals proceeding to Russia at this time must be prepared to assume the role of pioneers, *i. e.*, stand hardships and discomforts not met with in other countries. Such conditions can be tolerated by some, but others will find them unbearable. They may find themselves impaired in health, become discouraged and unhappy, resulting in regret for their decision to leave a peaceful civilized country despite the opportunity for more pay than now attainable at home. Without question, an engineer should not take children into Russia. Most people familiar with conditions there strongly advise against the taking of wives, unless they be strong, healthy, robust individuals, accustomed to discomforts and inclined to enjoy overcoming difficulties and the fighting of adverse conditions.

"It would be well before accepting employment to confer with several engineers who have worked in Russia under comparable conditions.

Legal Status and Personal Safety

"An individual accepting employment under the Soviets must appreciate that he is working for an autocratic government. The United States has no diplomatic relations with Russia and there is no United States ambassador or consul to whom he can appeal if he feels himself wronged.

"Adequate reasons may develop for the breaking of a contract, but still the government has the arbitrary power to take away passport and food card, and/or prevent the employee from leaving the country. In such case great difficulty may be experienced in subsisting. The engineer may be fined or forced to do menial work in punishment for alleged breaking of his contract.

"Up to the present foreigners have been safe in Russia, but will this continue to be the case? Fear is entertained that if the five-year plan should not eventuate as represented to the people, or if some plant or installation should fail to deliver anticipated results, the Soviets will seek a "scapegoat." If so, who would be more suited to that role than the foreign engineers in charge of that particular piece of work? Many people have been executed or imprisoned as "scapegoats." So far as we know, the victims thus far have been Russians; but should desperate conditions arise, may not summary treatment be extended to the foreign elements? . . .

"What would be the position of a member of the profession upon return to the United States? . . . Is the experience to be gained in Russia apt to be useful? From numerous directions we hear of a lack of organization, of changing of plans on the whim of some committee, interruption of operations because some official considers another piece of work of more importance. The engineer in charge cannot on his own authority discharge or dispense with the services of his subordinates. It is doubtful if work carried on under such conditions provides experience an American engineer can capitalize upon his return home, and it may even depreciate his effectiveness as an executive.

Recommendations Concerning Service Contracts

"So far we have only enumerated some of the conditions in Russia that suggest points to be considered (by an engineer) when deciding to accept employment in that country. *If he decides that his particular situation is such that he must accept Russian work regardless of the known unfavorable conditions*, then he should if possible give preference to employment with some large American contractor or engineering firm, rather than attempt an individual contract with the U. S. S. R. . . .

"While the matter of performance of an employment contract by the Soviets is a matter of faith, on account of the impossibility of bringing any dispute before an American court, still as far as we know they have thus far shown a disposition to live up to the *letter of the contract*. This being so, it becomes important that the contract terms should embrace every possible contingency. No dependence whatever should be placed on verbal statements or assurances. It has been found repeatedly that assurances made here have no force whatever when the employee arrives in Russia.

"Whether going as an individual or as a member of a group, one should see that the following points, among others, are provided for:

"(a) Adequate provision for first-class transportation and expenses from America to place of employment *and return*.

"(b) . . . He should insist on receiving as large a portion as possible, certainly not less than 50 per cent of his remuneration, in dollars to be deposited or paid as directed in the United States. It must be remembered that foreign money can be brought out of Russia only to the extent to which it was taken in, less the amount the authorities decide he should have spent while in Russia. After residing in Russia for a certain length of time, no foreign money can be taken out. While a certain amount in Russian currency can be sent out, it has only a greatly depreciated value in foreign countries.

"(c) . . . Visitors to Russia are required to spend a certain minimum per day and the engineer should inform himself to what extent these regulations apply in his case.

"(d) A non-resident citizen is subject to our Federal income tax, but should be free from taxation by the Soviet Government on amounts deposited in this country to the citizen's credit. A definite understanding should be had as to the amount of taxes on salaries paid in Russia, as well as on all other taxes.

"(e) Provision of living quarters, domestic servants, water, heating, light, cooking and sanitary arrangements, either free of charge or at a definite price.

"(f) Fuel for heating and cooking and price thereof.

"(g) Supply of food and privilege of purchasing food, clothing and other supplies at commissaries established for foreign diplomats and engineers.

"(h) Privilege in regard to the taking in and importing into Russia later of foodstuffs, clothing, toilet articles, etc., free of duty coupled with *guarantee of arrival.*

"(i) Outlining of duties and responsibilities of service to be renderd.

"(j) The conditions under which employees are privileged to resign with safe conduct and expenses back to the United States, etc.

"(k) Discontinuance at one job not to give Soviet the privilege of transference to another.

"(l) Various Soviet industrial organizations, operating through the Amtorg Trading Corporation in New York, engage American engineers and technicians to work in Russia. As there are no relations between the government of the United States and that of the Soviet Union, the signature of the Amtorg for itself as an American corporation should always be obtained to any contract.

"The foregoing observations should be regarded only in the light of general suggestions. They are intended to call attention to the unusual circumstances surrounding the Russian situation; each case will require more individual treatment than is possible in a general report. *—Respectfully submitted, Henry Krumb, chairman; Lucius W. Mayer, J. V. W. Reynders, Edgar Rickard.*"

Electric Steam Generator For Sterlization Processes

Packed heat from a new type of electric steam generator displaces steam from high-pressure mains, it is declared by Howard Bidwell and Linus H. Jones of the Massachusetts Agricultural Experiment Station, Amherst, in a report to the American Chemical Society.

"The new electric generator," the report says, "is applicable for use with hospital sterilizers, pressure-cooking retorts, or in any industrial process where a large quantity of steam is necessary for a short period of time.

"There are many processes in the scientific and industrial fields that require large amounts of steam for periods of short duration. High-pressure steam is expensive and its cost is becoming so excessive that this method is almost prohibitive during the non-heating months. There is also a labor cost if the law of the state demands a licensed operator.

"This generator has a reservoir in which heat is packed and stored. The result is that within thirty seconds from the time of closing the autoclave the required sterilizing pressure is registered. This may be obtained at any time by throwing a switch and opening two valves.

"The principle employed in the action of this boiler is that law of physics which governs the varying boiling points of water under different pressures. Depending upon the water capacity of the generator, irrespective of the steam space, any desired volume of steam at a lower pressure can instantly be made available by suddenly relieving the pressure on the generator.

"The use of fuel or electric steam generators that build up a sterilizing temperature in a retort decreases the working efficiency of the autoclave and its attendant. Time consumed in heating and cooling a large volume of water means time lost. The most satisfactory method is that which gives a sterilizing temperature immediately and allows one to stop the supply of heat as soon as the charge has been sterilized. The new electric steam generator gives all that can be desired as a source of steam and heat."

Saluda Completed To 162,500 Kva. Capacity

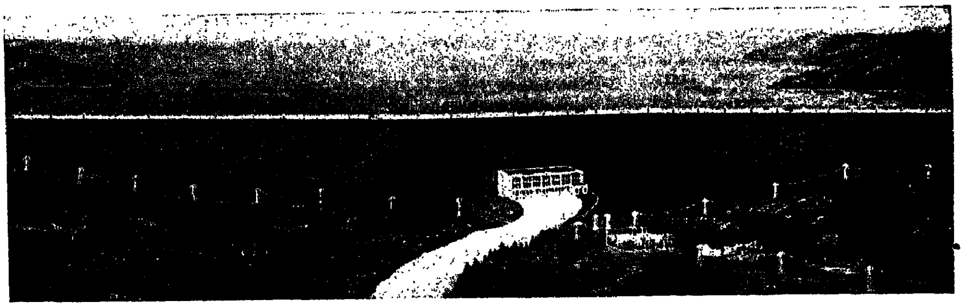
Completion of the Saluda development of the Lexington Water Power Company, subsidiary of the Associated Gas & Electric Company, injects another important factor into the industrial power situation of the southeastern states. The installation is on the Saluda River nine miles above its junction with the Broad River at Columbia, S. C., where a 7,838-ft. earth dam with its crest at El. 372,208 ft. above the river bed forms the Lake Murray reservoir which is 41 mi. long and 14 mi. wide at its widest point. With an area of 78 sq. mi. this reservoir has a capacity of some 2,340,000 acre ft., which is said to represent 200 million kw-hr. at normal rates of withdrawal under average conditions. At its base at the power house the dam is 998 ft. thick; 1,150 ft. thick at its base at its maximum point, and contains 11,000,000 cu. yd. of earth fill.

The present installation which represents two-thirds of the expected ultimate plant capacity includes four 40,625-kva., 0.8-power-factor, 13.8-kv., three-phase, 60-cycle, 138.5-rev. per min. vertical generators direct-connected to 55,650-hp. Francis turbines, designed to develop full rated horsepower at 180-ft. head with full gate opening. The generators are of the single-bearing overhung-rotor type, having a thrust and a steady bearing in the same oil pot beneath the rotor.

At the present time, surge tanks are installed only for units Nos. 1 and 3, which units it is intended will do the regulating for the plant with high-speed governing equipment, whereas units Nos. 2 and 4 are expected to run practically at constant load with slow-speed governing.

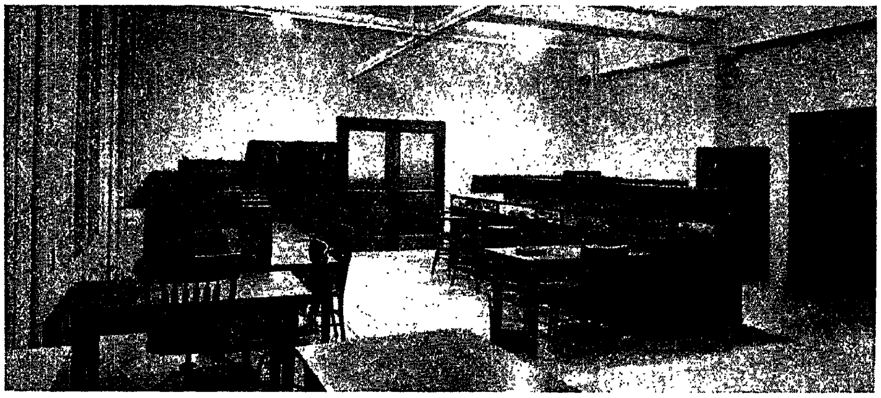
The plant output is stepped up to 125.6 kv. through 40,000 kva. outdoor transformer banks at the plant, and carried approximately a thousand feet down the stream to the high-voltage switching substation whence it is distributed throughout the interconnected Associated Gas & Electric system.

Engineers for the project were Murray & Flood, and W. S. Barstow & Company, Inc.; Albert S. Crane was consulting engineer. Designs for the dam, conduits, intakes, surge tanks and spillway were made by the J. G. White Engineering Corporation, and the designs for the power house and substation were worked out by W. S. Barstow & Company, Inc. The dam, conduits, and intakes were built by the Arundel Corporation, and the power house, spillway, and substation, by W. S. Barstow & Company, Inc. The steel-pipe conduits were furnished by the Reeves Brothers Company; the penstocks and surge tanks by the Chicago Bridge & Iron Company; the intake gates by Phillips & Davies, Inc.; the turbines, butterfly valves and Radial gates by the S. Morgan Smith Company; the turbine governors were built by the Woodward Governor Company; the generators by Westinghouse Electric & Manufacturing Company; and the transformers by General Electric Company



Artists sketch of Saluda development in South Carolina

Special Laboratory Lighting at Penn State



AN UNIQUE and important improvement in laboratory lighting was demonstrated recently in the completion of a new building at Pennsylvania State College. In this, lighting is provided by direct prismatic glass globes, the lower half of each being color-correcting, blending well with daylight and entirely satisfactory for night use. Sufficient unmodified light passes through the upper half of the globe to illumine the ceiling, and overbalance the unfavorable appearance at night of daylight lamp equipment, at the same time in no way interfering with the identification of colors in specimens being studied. With this type of fixture 300-watt lamps with approximately 11-ft. centers produce an intensity of from 18 to 20 foot-candles on the tables. . . . (Contributed by Prof. D. L. Markel, State College, Pa., through the A. I. E. E. committee on the production and application of light.)

N. E. L. A. Annual Convention June 8-12

The Atlantic City Auditorium and Convention Hall will be the headquarters of the fifty-fourth annual gathering of the National Electric Light Association.

The convention will open officially June 8, although the registration desk will be active June 6 and 7; the exhibition Monday, June 8, at 9 a. m., continuing daily throughout the convention dates. Special features of the convention's program will be a "national employee speaking contest" on Monday with award of the prize on Thursday. On Tuesday, June 9, there will be a "seaview day" for the ladies. A diversive program fitted to this special season but in no way neglecting technical values will be offered by this convention.

Purdue University Receives Airport Site

In proof of his faith in the future of aeronautics and as another evidence of his foresight for Purdue University, David E. Ross, president of the board of trustees of the university, has purchased and deeded to the university three tracts of land totaling 157 acres, to be developed as a Purdue airport. The tract which is level and free of trees lies half-mile southwest of the campus and adjoins Edgewood farm owned and operated by the university. This if it were found desirable to do so at a later date could be used as part of the landing field giving a combined tract of 317 acres on level land.

The area purchased by Mr. Ross has been officially inspected by representatives of the U. S. Department of Commerce and received high approval for aircraft purposes. Adequate markings have been placed for the new airport and the field has been included in the new airport map of this region prepared by the Department of Commerce.

Triennial Montefiore Prize Award Now Open

Constituting interest on 150,000 Belgian francs, distributed triennially in international competition for the best original work presented on scientific advancement and progress in technical application of electricity in every field, the Montefiore prize award now is open again to candidates.

To be eligible an achievement must have been made public at some time during the three years immediately preceding the period of award. Papers either signed or anonymous are acceptble in manuscript or reprint form; they must, however, have been edited in either French or English; also, all manuscripts must be typewritten.

By a four-fifths vote of the board of examiners composed of five Belgian and five other electrical engineers, one-third of the amount available may be designated as an unsecured loan to a person whose work does not fall completely within the ritual of the governing program but which demonstrates a new thought in connection with development of importance in the sphere of electricity.

Can You Supply These Transactions?

The engineering department of the University of Tennessee, through its trustee Paul J. Kruesi, is making an appeal for the following back volumes of A. I. E. E. Transactions:

1884-87 (inclusive of vols. I, II, III and IV; vols. I and III desired if available in separate unbound form)
1887-88 (vol. V)
1888-89 (vol. VI)

Mr. Kruesi will be grateful to anyone willing to spare these copies to complete the University's library records. Address Miss Laura Kersey, Librarian, Engineering Library, University of Tennessee, Knoxville, Tenn.

Outdoor Generators For New Bagnell Dam

First shipments on an order for waterwheel generators to be used at the new Bagnell Dam on the Osage River, Missouri, are being made from the Westinghouse Electric and Manufacturing Company, East Pittsburgh, to the Union Electric Light and Power Company, St. Louis, Mo. The six generators are of the so-called outdoor type and will be built into the foundation of the spillway. Instead of the usual power house, the units will simply be covered with large cast iron lids which may be removed as desired by a large traveling crane. Only the controls will be housed inside of rooms built into the wall of the dam.

In operation the generators will become a part of the 201,000-hp. development on the Osage, the Bagnell Dam being a structure 148 ft. high from bedrock to highway and forming a reservoir 129 mi. long with an area of 95 sq. mi. and 1,300 mi. of shoreline. In the development of this reservoir it has been found necessary to move an entire town four miles to higher ground. The Bagnell Dam is located 130 mi. southwest of St. Louis.

Engineering Foundation

Education Research Committee Established

Engineering education during the past decade has received much serious attention from engineers, educators, industrialists, philanthropic foundations, and various government agencies. Through the Society for Promotion of Engineering Education, Engineering societies have cooperated with engineering colleges and because of the interest expressed by its founder societies and the need for help in prosecuting the work which the Education society has had in hand, the Engineering Foundation has devoted much energy to the subject. Encouraged by discussion at its recent meetings and conferences which were attended by many men prominent in education, industry, and engineering, and advised by a small group of educational research men, the Foundation established an education research committee:

Harvey N. Davis (chairman), president of Stevens Institute of Technology; A. S. M. E.

Walter F. Whittemore, Hotel Woodstock, New York; A. S. C. E.

William B. Plank, Lafayette College; A. I. M. M. E.

Harold B. Smith, Worcester Polytechnic Institute; A. I. E. E.

Robert I. Rees, assistant vice-president American Telephone and Telegraph Company; Society for Promotion of Engineering Education.

Alfred H. White, professor of chemical engineering, University of Michigan; A. I. C. E.

Alexander R. Stevenson, Jr., General Electric Company, Schenectady, New York; The Engineering Foundation.

This committee was charged with ascertaining the attitude of the engineering societies toward a project to comprise:

(a) Fundamental research in engineering education.

(b) Vocational guidance, especially for youths in preparatory schools, including booklets giving information about engineering.

(c) Empirical investigations of objective tests and comprehensive examinations.

In preparation for outlining a project of reasonable dimensions the committee is making a preliminary study of:

(1) Placement of graduates of secondary schools (and other young persons) in engineering colleges.

(2) Objective tests, for various purposes.

(3) Placement of engineering college graduates in industry and business.

(4) Correction of the maladjustment of certain students and graduates to their social and other environments.

(5) What Engineering Foundation can do to be to engineering what the Chemical Foundation has been and is to chemistry, in extending the public's knowledge and appreciation of engineers and their work.

Standards

I. E. C. Announces Revision of Electrical Machinery Rules

Final approval of the I. E. C. *Publication No. 34* containing the revised I. E. C. rules for electrical machinery was given by the U. S. National Committee of the International Electrotechnical Committee at a meeting held February 6, 1931. In its present form this publication was drawn up at the I. E. C. plenary meeting held at Oslo in July 1930; it represents, however, the culmination of ten years of continuous effort, during which time it has been the subject of debate at seven formal international I. E. C. meetings.

The revised publication represents the agreement of national committees of the I. E. C. in more than a dozen countries, and constitutes an international consensus of opinion concerning the more usual requirements of electrical machinery standards similar to those now a part of the various national standards, such as the A. I. E. E. Standards in the United States, the B. E. S. A. Standards in Great Britain, and the V. D. E. in Germany. It covers all sizes of transformers and rotating electrical machines except traction motors, and supersedes the 1920 edition. Other I. E. C. Standards publications include the following:

Number	Title	Price
27.	International Symbols (first part) Letter Symbols	$0.50
28.	International Standard of Resistance for Copper	0.50
34.	**I. E. C. Rules for Electrical Machinery**	**1.00**
35.	International Symbols (second part) Graphical Symbols for Heavy-Current Systems	1.00
37.	Standard Dimensions of Bayonet Lamp Sockets and Caps	0.25
38.	I. E. C. Standard Voltages	0.25
39.	International Rules for Traction Motors	0.25
41.	I. E. C. Publication on the Testing of Hydraulic Turbines	0.50
43.	I. E. C. Recommendations for Alternating Current Watt-Hour Meters	0.50
44.	I. E. C. Recommendations for Instrument Transformers	0.50

Copies of any of these publications may be obtained from the secretary of the U. S. National Committee, I. E. C., 33 West 39th Street, New York, N. Y. They may be obtained also from the central office of the commission by addressing Mr. C. le Maistre, 28 Victoria Street, London, S. W. 1, England. In ordering this literature it is essential that the request be accompanied by the proper remittance.

How to Obtain the New Standards Yearbook

The 1931 volume of the Standards Yearbook compiled by the National Bureau of Standards and containing authentic and carefully investigated information on (I) Standardization in transport (in symposium form); (II) International standardizing agencies; (III) National standardizing agencies; (IV) Federal standardizing agencies; (V) National Bureau of Standards; (VI) Municipal, county, and state purchasing agencies; (VII) General standardizing agencies; (VIII) Standardizing activities of technical societies and trade associations; (IX) Bibliography on standardization; and (X) a complete Index, is now off the press. In the transport division (I) falls such facts as relate to research and experiment in aviation, automotive, and highway development and safety; railroads, pipe lines, elevators, marine navigation, speech and power transmission, and other important government activities. The volume also reports an annual bibliography on standardization prepared by the Library of Congress. The price of the book for domestic distribution is $1.00; it is obtained by addressing the Superintendent of Documents, Government Printing Office, Washington, D. C.

New Standards Data.—A new compilation of data entitled, "Measurement Units and Standards," has been issued recently by the American Institute of Weights and Measures; a copy of this book may be obtained gratis by applying to the Institute, William E. Bullock, secretary, 33 Rector Street, New York. In addition to the data on units and standards, the book contains an article recommending *timex* and *spacex* as names for the Einstein specialization of basic time and space. It also contains a description of the difference between a *unit* and a *standard*, prompted by the lack of unanimity existing in reference publications.

Personal

High British Award to Francis Hodgkinson

Francis Hodgkinson (Asso. '02), consulting mechanical engineer for Westinghouse Electric & Manufacturing Company and well known in marine circles for his many contributions to efficiency by improvement of steam-driven machinery and electrical apparatus, has received the Willans Premium, a high British engineering honor awarded by the Institution of Mechanical Engineering, London. The award was given for the best paper published in the *Proceedings* of the Institution from 1925 to 1930 inclusive, and is being forwarded to Mr. Hodgkinson in the form of a gold medal. His prize-winning paper was entitled "Journal Bearing Practise."

The Willans Premium which may be awarded in the form of medals, books, or cash as the council may determine, was established 1897 to perpetuate the name of Peter William Willans for services rendered engineering and electrical science. It is awarded alternately by the Institution of Mechanical Engineers and the Institution of Electrical Engineers, for the best original paper coming before either institution, and dealing with—utilization and transformation of energy treated especially from the point of view of efficiency and economy. The award is made triennially, but may be carried over according to the judgment of the governing board.

FRANCIS HODGKINSON

Mr. Hodgkinson was associated with the late Sir Charles A. Parsons in early experiments and turbine developments in England. Following a term in the Chilean Navy and engineering work in Peru, he became associated with the Westinghouse company in 1896 when George Westinghouse was introducing the Parsons turbine in this country. When the South Philadelphia works were established in 1916, Mr. Hodgkinson was chosen chief engineer and in 1926 was advanced to the office of consulting mechanical engineer for all branches of the Westinghouse company.

Dr. Luckiesh Honored by Optometry Foundation

For his contributions in "constructive ideas for optometric research" Doctor M. Luckiesh (Mem. '15) has been awarded a fellowship in the Distinguished Service Foundation of Optometry, Cleveland, Ohio. The Foundation contends that through his many papers and lectures presented before the Optometric Association, Doctor Luckiesh has promulgated the understanding by the optometric profession of the part lighting plays in the conservation of eyesight.

M. LUCKIESH

The Distinguished Service Foundation which was established in Boston, March 1927, has as its purpose effort "to provide an agency for encouraging research, inventive and experimental work by practising optometrists, physiologists, physicists, illuminating engineers and others, to award gold medals and fellowships for such research and scientific attainments, and to encourage and aid men and women of marked proficiency to discover knowledge which that will benefit human vision."

James W. Welsh, (Fel. '14) who in the fall of 1929 became identified with the Cleveland Railway Company as assistant to its president, has resigned to come to New York to establish his own organization of traffic consultants. After seven years as executive secretary of the American Electric Railway Association Mr. Welsh went to Cleveland a nationally recognized authority on electrical engineering and traffic problems, and a specialist in traffic engineering. He has devoted his time to studies of proposed coordination of rapid transit and surface lines, and the application of zone-fare principles to the Cleveland Railway system. By the president of that system he is accredited with having made possible the speeding up of surface lines and the realization of substantial operating economies. Mr. Welsh contends that the continued growth and development of our cities depends as much upon the efficient use of existing transportation facilities as upon the provision of additional ones; that we should be sure we are getting 100 per cent use from these facilities before assuming additional burdens. In 1924 he was a member of a special committee which studied European transporation conditions for the American operators of electric railways.

O. S. Peters (Assoc. '11) for many years conspicuous by his achievements as an inventor of electrical devices, has been made the recipient of the John Scott bronze medal for the invention of a telemeter for recording strains and pressures. The invention may be said to be the outgrowth of ten years' effort in technical research work with the Bureau of Standards. The instrument has been in commercial use for a number of years and has proved its value in an extended field of utility. Mr. Peters, after the completion of his technical studies at Montana State college, returned the following year as instructor in electrical engineering. His term of service with the Bureau of Standards was from 1910 to 1918, as assistant physicist.

A. W. Leonard, (Mem. '29) connected with Stone & Webster interests for the past 36 years, and president of the Puget Sound Power & Light Company, Seattle, retired from the presidency April 1 to assume the chairmanship of the board of directors of the parent organization, the Engineers Public Service Company, with offices in New York City. His predecessor in this capacity was Charles W. Kellogg, (Mem. '23), who has managed the Stone & Webster properties for an extended number of years, and who is now retiring after a most successful record.

B. A. Behrend (Fel. '12) of Wellesley Hills, Mass., has just had the honorary degree of doctor of engineering conferred upon him by the University of Darmstadt "for meritorious work in the construction of induction machines." Mr. Behrend has gained prominence in the American engineering world both by the assistance he has rendered the Institute in the past with his work on its committees and by his various other worthy engineering affiliations. He is at present carrying on a successful consulting engineering practise of his own at Wellesley Hills.

Donald M. Simmons (Fel. '28) chief consulting engineer of the General Cable Corporation, New York City, has been elected president of the Insulated Power Cable Engineers' Association. Other officers are T. F. Peterson, cable engineer of the American Steel & Wire Company, New York, vice-president, and R.J. Wiseman, (Fel. '27) chief engineer of the Okonite Company, Passaic, N. J., secretary and treasurer. The retiring officers are G. M. Haskell, president; W. A. DelMar, vice-president; and H. G. Burd, secretary and treasurer.

L. J. Bourke (Assoc. '23) for the past several years assistant to William H. McGrath (Mem. '20), vice-president of the Puget Sound Power & Light Company, Seattle, received appointment effective March 1, 1931, as manager of the company's southern district at Chehalis, Washington. Homer R. Chitty, Jr. (Assoc. '28), who has held office as manager of that district for some time past has been transferred to Tacoma in charge of the southwestern district of the company.

L. A. S. Wood (Mem. '24) manager of exterior lighting section, Westinghouse Electric & Manufacturing Company, Cleveland, Ohio, has been given complete charge of a new division centering all lighting activities of the company into a movement of coordination at the Cleveland works. This concentration represents the culmination of a nucleus plan made when the Westinghouse lighting activities first were established in Cleveland.

Clarence A. Mayo (Assoc. '13) electrical engineer of the Malden Eectric Company, Malden, Massachusetts, recently became assistant manager of the Eastern Massachusetts Electric Company. His headquarters will be in Salem. Mr. Mayo is a past chairman of the Electric Lines Club of New England and for two years chairman of the engineering section of the New England division of the N. E. L. A.

K. C. Christiansen (Mem. '21) for over ten years has been affiliated with the Electric Bond & Share Company and its subsidiary the Phoenix Utility Co.; now he has engaged with the Safe Harbor Water Power Corporation, Lexington Building, Baltimore, Md.

John Dibblee (Mem. '26) general superintendent of the Hydro-Electric Power Commission, the Niagara district, has been assigned to the recently created position of assistant to Henry C. Don Carlos (Fel. '18) the operating engineer of the provincial system.

John H. Muggli (Mem. '31) has been transferred from the Shell Oil Company's Martinez Refinery to the home office at San Francisco, where he will continue his capacity of electrical engineer.

Obituary

Robert J. Scott, (Fel. '13) professor emeritus of the University of New Zealand, Horomanga Island, Port Levy, Banks Peninsula, New Zealand, and for many years local honorary secretary of the Institute for New Zealand, passed away November 8, 1930.

He was born at Plymouth, England, September 14, 1861, the son of Rear Admiral Scott and a cousin of Captain Scott the South Polar explorer. He attended the Abbey School, Beckenham, King's College, London, and the Royal School of Mines, where his course included electrical engineering and management. Supplementing this by private tutelage in mechanical drawing and civil engineering under General H. Y. D. Scott, F. A. S., C. B., Director General of Works, England, thereafter he was employed under his father, Rear Admiral Scott, R. N., as superintendent of naval gun carriages at Woolwich Arsenal and at Chatham. In 1881, after extensive railway experience in England, he joined the New Zealand railway service, advancing from the position of locomotive draftsman to manager of the Addington works, designer for the locomotive department, and finally becoming acting locomotive superintendent. In 1888 he was appointed part time lecturer in engineering at Canterbury College, University of New Zealand; two years later he became lecturer in charge of engineering and then professor in charge. At the time of his retirement in February 1923, Professor Scott as the inventor and operator of many of its railway and transportational improvements was probably one of the most prominent figures in New Zealand's world of engineering. The School of Engineering is a lasting memorial to his foresight, initiative, and powers of organization, and, to quote, "it is fitting that the culmination of his work should be its recognition by the government as the national school of engineering of the Dominion." He joined the Institute as an Associate in 1902, advancing to the grade of Fellow in 1913. For an extended number of years he held chairs of engineering and electricity in the University of New Zealand. He was a member of the British Institution of Civil Engineers, serving on its advisory committee, and was also a member of the Institution of Mechanical Engineers.

Edward Dwight Priest, (Assoc. '12) for many years designing engineer in the railway department of the General Electric Company, died at his home in Schenectady March 26, 1931; he was 70 years of age. A native of Northfield, Massachusetts, and a graduate of Worcester Polytechnic Institute (1884), he was employed in 1887 by the Thomson Houston and General Electric Companies where his time was devoted chiefly to railway motor design, in charge of the work. One of his first achievements was the conception of a special-type railway motor light in weight for use on elevated lines. Railway electrification problems were his chief interest and here his contributions to development and improvement were of the greatest value. In 1888 he was the originator of the first box-frame motor ever marketed by his company; this was cast in one piece. In 1901 the electrification of the Manhattan elevated was one of a group of achievements under the leadership of Mr. Priest; as was also a special design of locomotive for the Boston & Ohio Railroad. When William B. Potter became railway department engineer of the General Electric Co. in 1895 he appointed Mr. Priest designing engineer in charge of railway motors, a position which he held until his retirement in 1926.

Beverly L. Worden, (Mem. '27), president of Cutler-Hammer, Inc., New York and Milwaukee, passed away at his home in West Orange, N. J. after an illness of several months. He was born in Chicago 61 years ago and received his B. S. in Civil Engineering from the University of Wisconsin in 1893. In 1901 he founded the Worden-Allen Company of Milwaukee, and in 1909 the Lackawanna Bridge Company of Buffalo; of both of these companies Mr. Worden was president, of the first until 1921, and of the latter until 1924, when he became general manager of the Newark Bay shipyard, Newark, New Jersey, building steel ships for the Emergency Fleet Corporation. For a period prior to the United States' entry into the war he was general manager also of the Submarine Boat Corporation. Early in 1923 Mr. Worden became identified with Cutler-Hammer, Inc., as its vice-president and director, later being chosen president. He was a representative member of several engineering organizations inclusive of The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the Western Society of Engineers. For the past number of years he had also been a member of the National Electrical Manufacturer's Association.

Nathan B. Ambler, superintendent of the hydroelectric plant, U. S. Engineering Department, Wilson Dam, Florence, Ala., and well-known as an electrical production engineer, died suddenly April 11 while driving his car in that city to which he had gone as a member of the staff of Hugh L. Cooper, of the Cooper Engineering Corp., consulting engineer for the construction of the Wilson Dam.

A native of Chatham, New York (1876), Mr. Ambler took a four years' course in the electrical engineering department of Columbia University, and for a while thereafter was employed as electrician of the Metropolitan Street Railway Company. This led to work with the Interurban Street Railway Company, which he served as substation foreman. Prior to his association with the Cooper Engineering Corporation, he was superintendent of a Niagara Falls power plant. His membership in the Institute dates from 1903.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institutue records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Collinot, Marcel A., 88 Sherman Ave., Newark, N. J.

Davis, R. H., Westinghouse E. & M. Co., East Pittsburgh, Pa.

DiLucci, A., Box 1051, Chicago, Ill.

Duane, George B., Otis Elevator Co., Yonkers, N. Y.

Gale, R. E., 706 N. 19th St., Boise, Idaho.

Kigar, D. F., 1403 Minnie St., Port Huron, Mich.

Muncy, V. E., Ohio Mechanics Institute, Cincinnati, Ohio.

Prehn, Victor N., 940 Broad St., Newark, N. J.

Van Wyck, P. V. R., Summit, N. J.

Local Meetings

Nebraska Sections Meet with Student Branches

The Nebraska sections of the A. S. M. E. and A. I. E. E. held their annual student meeting in Omaha on April 9, 1931, in cooperation with the Student Branches of both societies at the Universities of Nebraska and South Dakota.

Morning inspection trips included the 4th and Jones Streets plant of the Nebraska Power Company, or the Cudahy Packing Company plant. Afternoon trip opportunities included the Orpheum Theater air conditioning, or Ford Assembly Plant; WOW Broadcasting Station; Northwestern Bell Telephone Building; New Union Station, or Omaha Steel Works.

Dinner was held at the University Club, and during the student program, Phil Ehrenhard, chairman, University of Nebraska Branch, A. I. E. E., served as toastmaster. There was a brief address by Dean H. S. Evans, vice-president, District No. 6, A. I. E. E., and the following talks were given by students:

Human Nature in Engineering, by R. O. Rensch, senior, M. E., University of Nebraska.

Having a Hobby, by A. Steponaitis, chairman, University of South Dakota Branch, A. I. E. E.

Audible Light, by W. E. Stewart and S. M. Geis, seniors in E. E., University of Nebraska.

Several musical numbers were given by students of the University of Nebraska. There were 105 in attendance.

Boston Section Holds Student Meeting

Continuing a plan inaugurated in March 1930, the Boston Section and the student groups of Harvard University, Massachusetts Institute of Technology, Northeastern University, and Tufts College held a joint meeting at the Massachusetts Institute of Technology on the evening of March 26, 1931, with an attendance of 215. During a buffet supper, the students interested in specific fields of electrical engineering were seated at tables with engineers practising in that same field. Thus each student was given opportunity to receive information and advice regarding his favorite kind of electrical work.

M. B. Lambert, vice-president, Westhouse Electric & Manufacturing Company, gave an address on "The Engineer and His Outlook;" this proved to be very interesting to the students and the Section members. There was considerable discussion by both groups, and the meeting was considered one of the most successful of the year.

Toronto Section Holds Luncheon and Evening Meeting

In honor of President Lee and National Secretary Hutchinson, the Toronto Section held a luncheon at the Royal York Hotel, Toronto, March 27, 1931. Present were: D. A. McKenzie and G. D. Floyd, respectively chairman and secretary of the Section; C. E. Sisson and W. L. Amos, respectively vice-president and secretary of District No. 10; A. B. Cooper, director of the A. I. E. E.; I. M. Maclean, J. A. Magley, V. G. Smith, and W. F. Sutherland, members of the Section's executive committee; and T. R. Rosebrugh, F. A. Gaby, H. W. Price, W. A. Bucke, E. T. J. Brandon, W. F. Wright, A. H. Hull, F. R. Ewart, W. P. Dobson, S. E. M. Henderson, C. E. Schwenger, H. C. Don Carlos, M. B. Hastings, E. M. Wood, and F. F. Ambuhl, past chairmen of the Section.

In the evening, G. L. Lillie of the

Toronto Hydro-Electric System presented a paper "Factors in Design of 115/230-Volt Distribution in a Modern Residential District." President Lee addressed the meeting, and his description of problems he had encountered in development of water power sites in Quebec was especially interesting. National Secretary Hutchinson outlined the progress in Institute affairs, and emphasized the desire for constructive criticism and suggestions for the further development of ELECTRICAL ENGINEERING. The attendance was 91.

San Francisco Section Meets With Students

On March 27, 1931 the San Francisco Section held a meeting specially arranged to bring together the Section members and University of California, University of Santa Clara, Stanford University Student Branches. At a dinner preceding the program each student was seated with an engineer practising in the particular field in which the former was especially interested, thus offering excellent opportunities for helpful exchange of information and experiences.

The address of the evening was by R. R. Newell, professor of medicine and director of the department of radiology, at Stanford University Medical School, on the subject "The Use and Misuse of Electricity in Medicine," and was received with great interest. Dr. Newell exhibited many instruments used in making examinations.

Attendance at the dinner and at the address was 118 and 180, respectively.

Pittsfield and Schenectady Section Competition

Following the plan inaugurated last year to encourage their younger members to participate in programs, the Pittsfield and Schenectady Sections held joint meetings in Pittsfield March 17, 1931, and Schenectady April 3, 1931, for the presentation of papers by section members less than 30 years of age and who had not previously presented Institute papers. The programs were as follows:

PITTSFIELD

OPERATION OF THE MERCURY BOILER TUBE WITH HIGH THERMAL STRESSES, by T. C. Ohart, Schenectady.

PULPS AND PAPER IN THE ELECTRICAL INDUSTRY, by M. B. Newell, Pittsfield.

A METHOD OF DETERMINING POWER TRANSFER LIMITATIONS OF LOW-VOLTAGE A-C. NETWORKS, by R. G. Lorraine, Schenectady.

NETWORK TRANSFORMERS, by P. L. Christensen, Pittsfield.

NONTECHNICAL FACTORS AFFECTING THE ELECTRICAL INDUSTRY, by S. A. Holme, Schenectady.

PRECISE FREQUENCY DETERMINATION, by C. W. Ransom, Pittsfield.

SCHENECTADY

NOISELESS ROTATING MACHINERY, by S. J. Levine, Pittsfield.

THE POLYCYCLIC THYRATRON INVERTER, by R. S. Thurston, Schenectady.

LIGHTNING STUDIES ON SMALL HIGH-VOLTAGE TRANSFORMERS, by M. F. Beavers, Pittsfield.

HIGH-VOLTAGE IMPREGNATED-PAPER POWER CABLES, by D. R. Carpenter, Schenectady.

A NEW DEVELOPMENT IN IRON-CORE REACTORS, by T. A. Wilson, Pittsfield.

PREDETERMINATION OF OVERVOLTAGE IN ELECTRICAL SYSTEMS SUBSEQUENT TO LOSS OF LOAD, by J. W. Butler, Schenectady.

Prizes were awarded after consideration of the contents of the papers as well as the presentation. At the Pittsfield meeting, T. C. Ohart of Schenectady received the first prize, and S. A. Holme of Schenectady and C. W. Ransom of Pittsfield tied for second. The total numbers of points were Schenectady 496.3; Pittsfield 445. 85 attended the meeting, and 60 the dinner preceding it.

At the Schenectady meeting, J. W. Butler of Schenectady received the first prize, and T. A. Wilson of Pittsfield received second prize. The total numbers of points were, Schenectady 512.8; Pittsfield 486.4. 150 attended the meeting, and 90 the dinner preceding it.

Student Convention At Swarthmore College

The seventh annual local student convention sponsored by the Philadelphia Section was held at Swarthmore College on March 16, 1931, with seven schools participating: namely, Drexel, Haverford, Lafayette, Lehigh, Pennsylvania, Princeton, and Swarthmore. The program of the morning session was as follows:

WELCOME—Dean Raymond Walters, Swarthmore College

AN AUTOMATIC TIMER FOR RACES, by E. A. Speakman, Haverford College, 1931

VISUAL TESTING DEVICES, by O. H. Schuck, University of Pennsylvania, 1931

ELECTRICAL DETERMINATION OF TENSILE STRENGTH, by William MacNamee, Princeton University

Discussion of above papers.

THE BARTOL LABORATORY, by Dr. T. H. Johnson, Franklin Institute

Those attending the convention were guests of Swarthmore College at luncheon, afterward separating into three groups, according to preference, to visit the Deepwater generating station of the American Gas & Electric and the United Gas Improvement Companies, the Lamokin substation of the Pennsylvania Railroad Company at Chester, Pa., or the General Electric Company switching equipment factory at Darby, Pa.

The latter part of the afternoon there was an inspection trip through the College buildings, followed by a dinner in the Whittier House.

The evening program included an organ recital, by Professor L. R. Shero of Swarthmore College, and the presentation of two papers:

LIFE OF HENRY, by R. M. Mitchell, Swarthmore College, 1931

LIFE OF FARADAY, by W. H. Radford, Drexel Institute, 1931

Three prizes were awarded for the presentation of student papers during the morning session, E. A. Speakman, receiving the first; O. H. Shuck, the second; and William MacNamee, third. Skits were presented by Drexel and Swarthmore students. The registration was 181.

Future Section Meetings

Cleveland

May 21, 1931—Annual dinner meeting. Speaker—W. S. Lee, president and consulting engineer, Duke Power Company, and president, American Institute of Electrical Engineers.

Detroit-Ann Arbor

May 19, 1931—Subject and speaker to be announced later.

June 20, 1931—Spring frolic.

Lehigh Valley

May 16, 1931—Annual meeting. INDUSTRIAL PLANNING FOR THE FUTURE, by E. C. Stone, assistant to senior vice-president, The Philadelphia Company. Meeting to be held at Altamont Hotel, Hazleton, Pa.

Niagara Frontier

May 15, 1931—Subject and speaker to be announced later.

Seattle

May 19, 1931—The best paper submitted in the annual competition for prizes will be presented at this meeting.

Sharon

May 5, 1931—The Contributions of Telephone Research to the Talking Motion Picture Industry, by J. O. Perrine, Associate Editor, *Bell System Technical Journal.*

Spokane

May 22, 1931—Annual dinner meeting. History of the Electrical Development of the Inland Empire, by John B. Fisken. Election of officers.

Toledo

May 22, 1931—Speakers—T. J. Nolan, Toledo Edison Co. and J. T. Greene, Police and Fire Alarm System.

June 12, 1931—Dinner and election of officers. Speaker—E. C. Stone, assistant to senior vice-president, The Philadelphia Company, and vice-president District No. 2, A. I. E. E.

Past Section Meetings

Akron

The Development of Electrical Engineering Since the Invention of the Incandescent Lamp, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. March 25. Attendance 350.

Inspection trip through the Hoover Suction Sweeper plant at North Canton. After dinner, M. L. Pierce gave a talk on Engineering in Selling. April 9. Attendance 80.

Atlanta

The Lighting of the Future, by A. L. Powell, Director, Edison Lighting Institute. Illustrated. Joint meeting with the A. S. M. E. Section. Dinner preceded the meeting. March 23. Attendance 80.

Baltimore

Artificial Lightning, by D. R. Rowland. After the speaker described the new d-c., high-voltage equipment installed at the Locke Insulator Company, those at the meeting adjourned to the laboratory of that company where a demonstration of the one and one-half million volt a-c. equipment and the two and one-half million volt d-c. equipment was given. March 20. Attendance 105.

Cleveland

Industrial Applications of Vacuum Tubes and Photoelectric Tubes, by E. L. Manning, General Electric Company. Illustrated and demonstrated with actual equipment. March 19. Attendance 210.

Connecticut

The Sun Lamp, by Paul Luckenbach, General Electric Co. Illustrated with slides. Meeting held at the Bridgeport Works of the General Electric Co. March 25. Attendance 40.

Dallas

Speed, Unemployment, and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engineering Corp. March 5. Attendance 98.

Engineer's Responsibility, by Dean F. C. Bolton, Texas A. & M. College. Dean George C. Shaad, University of Kansas, and vice-president, District No. 7, A. I. E. E., gave a talk on Institute activities. March 25. Attendance 74.

Denver

Engineering Considerations in the Design of Open Wire Line for Communication, by G. S. Dring, American Tel. & Tel. Co. Illustrated. Dinner preceded the meeting. March 13. Attendance 52.

Dinner and card party. March 20. Attendance 72.

Detroit-Ann Arbor

The Sound of a Shadow, by John B. Taylor, General Electric Co. Joint meeting with the Institute of Radio Engineers. March 17. Attendance 650.

"The United States Should Own and Operate Muscle Shoals" was the subject of a debate presented by students of the Stump Speakers Society from the University of Michigan and Detroit Institute of Technology. The judges decided in favor of the negative, which was supported by the team from the University of Michigan. Joint meeting with the Illuminating Engineering Society, sponsored by the educational committee of the Associated Technical Societies of Detroit. March 24. Attendance 100.

Erie

So-Called Network in A-C. Distribution, by P. F. Pugh, General Electric Co.;

Latest Methods in Mechanical Balancing, by F. M. Kirkpatrick, General Electric Co.;

Load Control, by O. E. Lang, Pennsylvania Electric Co. Members of the Technical Federation of Erie invited. February 17. Attendance 105.

Historical Developments in Electrical Engineering During the Past Fifty Years and the Influence of Same Upon Modern Life and Civilization, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. March 23. Attendance 120.

Fort Wayne

The D-C. Saturable Reactor, by B. A. Case, General Electric Co.;

The Theory of Probability, by W. J. Morrill and E. J. Schaefer both of the General Electric Co. March 12. Attendance 60.

Houston

Recent Developments in High Speed Relaying, Stability, and Lightning Protection on Transmission Systems, by I. T. Monseth, Westinghouse Elec. & Mfg. Co. February 26. Attendance 59.

Speed, Progress, and Unemployment, by Dr. William McClellan, vice-president, Stone & Webster Engineering Corp. March 3. Attendance 26.

The Professional Engineer, by Dean George C. Shaad, University of Kansas, and vice-president, District No. 7, A. I. E. E. March 23. Attendance 23.

Indianapolis-Lafayette

The Cathode Ray Oscillograph and Its Application to the Recording of Natural Lightning, by Professor R. H. George, Purdue University. Illustrated with slides. Joint meeting with the A. S. M. E. Section. April 3. Attendance 70.

Kansas City

Preservation Treatment of Pine Poles, by R. T. Blair, International Creosoting Co. Moving pictures followed. February 24. Attendance 50.

The Missouri River as a Factor in World Trade, by Frank V. Smith, General Electric Co. Film—"The All-Electric Ship California." Joint meeting of all the Engineering Societies in Kansas City. March 6. Attendance 350.

Lehigh Valley

Adventures in Science, by Oliver Ajer, General Electric Co. Demonstrated. Dinner preceded the meeting at the Hotel Sterling, Wilkes-Barre. March 27. Attendance 300.

Los Angeles

Annual joint meeting with the Student Branches of the University of Southern California and the California Institute of Technology, at which the following papers were presented by Students:

The Application of Engineering to the Development of Automobile

Lighting, by Walter Weiss, University of Southern California;

Wave-Form of Current in Converters, by Adin Mathews and Louis Hendrixson, University of Southern California;

Thyratron Theory, by G. W. Read, California Institute of Technology;

Discharge in High Vacuum, by E. O. Erickson, California Institute of Technology;

The Vacuum Switch, by Charles Lash, California Institute of Technology. At the conclusion of the technical session, the Aeronautics Laboratory, Astro-physics Machine Shop, and Electrical laboratories were inspected. March 10. Attendance 300.

Louisville

The Development of Louisville, by E. A. Erskine, Southern Bell Telephone & Telegraph Co. March 20. Attendance 30.

Madison

Some Factors Affecting Noise in Telephone Circuits Arising in Inductive Exposures, by W. C. Lallier, Wisconsin Telephone Co. March 11. Attendance 135.

Memphis

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. March 25. Attendance 61.

Milwaukee

Building Prosperity Avenue, by H. H. Magdsick, General Electric Co. Illustrated. Joint meeting with the Engineers Society of Milwaukee. March 18. Attendance 275.

The New Physics, by Professor Warren Weaver, University of Wisconsin. April 1. Attendance 93.

Minnesota

Oriental Travelogue, by C. P. Sigerfoos, Professor of Zoology. March 30. Attendance 45.

Niagara Frontier

The Progress of Electrical Engineering During the Last Fifty Years, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. Illustrated with slides. March 20. Attendance 125.

North Carolina

Annual spring meeting. Professor W. S. Rodman, vice-president, District No. 4, A. I. E. E. discussed Institute activities. The following papers were presented, all of which were illustrated with slides:

Telephone Facilities Used by Power Companies, by O. J. Huie, Southern Bell Telephone & Telegraph Co., and Blair Jenkins, Jr., Carolina Power & Light Co.;

Oil Circuit Breaker Developments, by R. M. Spurck, General Electric Company;

Insulation Value of Wood Pole Lines for Lightning Protection, by J. A. Jones, Carolina Power & Light Co. After dinner, Dr. C. L. Fortescue, Westinghouse Electric & Mfg. Co., gave a talk entitled Influence of Recent Lightning Investigations and Studies on Practical Design and Operation of High Voltage Transmission Systems. March 10. Attendance 120.

Oklahoma City

Speed, Unemployment, and Progress, by Dr. William McClellan, vice-president, Stone & Webster Engg. Corp. March 6. Attendance 102.

Rochester

Applications of the Light Sensitive Tube to Industry, by E. H. Vedder, Westinghouse Elec. & Mfg. Co. March 5. Attendance 201.

St. Louis

Development of the Modern Watthour Meters, by Fred Holtz, Sangamo Electric Co. Illustrated with slides. March 18. Attendance 70.

San Antonio

The Professional Society, by Dean George C. Shaad, University of Kansas, and vice-president, District No. 7, A. I. E. E. Following this lecture several motion pictures were shown. March 24. Attendance 78.

San Francisco

Industrial Application of Electricity, by Louis F. Leurey, consulting electrical engineer. The meeting was preceded by dinner at the Engineer's Club. February 27. Attendance 70.

Saskatchewan

Recent Developments of Directional Flying, by W. L. Laurie, Department of Civil Aviation at Ottawa. Illustrated. February 6. Attendance 29.

Schenectady

Historical Developments in Electrical Engineering in the Past Fifty Years, by Dr. A. E. Kennelly, Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology. March 27. Attendance 250.

Seattle

J. E. Hawe, Great Northern Railway, presented a paper on the result of two years' operation of the Great Northern Railway Electrification. Film—"Wildwood Coal Mines, 100 Per Cent Electrified." February 17. Attendance 81.

Spokane

Recent Developments in Electrical Engineering, by L. W. W. Morrow, editor, *Electrical World.* Dinner in honor of the speaker preceded the meeting. March 10. Attendance 27.

Syracuse

Recent Research Developments, by J. M. Stedman, Westinghouse Electric & Mfg. Co. February 23. Attendance 167.

Audible Light, by John B. Taylor, General Electric Co. March 9. Attendance 580.

Toledo

Vacuum Tubes and Photoelectric Cells in Industry, by E. L. Manning, General Electric Co. March 20. Attendance 800.

Toronto

Standardization, by B. Stuart McKenzie, Canadian Electrical Standards Association. March 13. Attendance 50.

Dependence of Future Research in the Applied Sciences Upon the Development and Refinement of Marketing, by W. W. Goforth, Cockfield Brown & Company. Illustrated. April 10. Attendance 41.

Urbana

Inductive Interference in Telephone Circuits, by W. W. Russell, Illinois Bell Telephone Co. March 11. Attendance 175.

Utah

The following five minute talks were presented by members of the Section:

The Mercury Turbine, by C. B. Shipp, General Electric Co.;

Contactor Control, by V. J. Del Duke, Utah Copper Co.;

Electrical Laboratory Equipment, by J. H. Hamilton, University of Utah;

Insulating Varnishes, by J. A. McDonald, General Electric Co.;

The Overhung Turbine, by B. E. Jordon, Utah Power & Light Co.;

The Synchronous Motor, by R. W. McNeil, Westinghouse Elec. & Mfg. Co. Film—"The Electric Ship." March 16. Attendance 42.

Worcester

Secondary Networks of Present Day, by D. F. Blake, General Electric Co. March 18. Attendance 45.

Past Branch Meetings

Alabama Polytechnic Institute

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. Professor Rodman also gave a brief history of the Institute. March 19. Attendance 68.

University of Alabama

Turbines, by Professor John M. Gallalee. Film—"Steam Turbines." March 9. Attendance 30.

University of Arkansas

Three films shown: "Dynamic America," "Steam Turbine with a Solid Rotor," and "Body and Soul." March 13. Attendance 53.

Armour Institute of Technology

Michael Faraday, by T. A. McGill, student;

Joseph Henry, by M. J. Schinke, student. March 20. Attendance 40.

University of British Columbia

Carrier Current in Telephony, by H. Van Allen, student. March 17. Attendance 14.

Polytechnic Institute of Brooklyn

A New Method of Scanning for Television, by Ivan Bloch, student;

Mercury Arc Rectification, by William Powers, student;

Breaking the A-C. Arc in Circuit Breakers, by Leonard Evans, student. Ivan Bloch received first prize and William Powers second prize. March 9. Attendance 26.

Bucknell University

Life and Works of Joseph Henry, American Physicist, by Percy Hort, Branch secretary. Film—"Steam Turbine with a Solid Rotor." March 9. Attendance 9.

Talks on the life and work of Archimedes, Galileo, and Sir Isaac Newton, by William Griffith, student. March 30. Attendance 8.

California Institute of Technology

Joint meeting with the Los Angeles Section and the University of Southern California Branch at which six papers were presented by students. (See report under Past Section Meetings).

University of California

Two films shown as follows: "Atomic Hydrogen Welding," and "Straight-Line Production of Induction Motors." Joint meeting with the A. S. M. E. March 11. Attendance 75.

Inspection trip to the Newark substation of the Pacific Gas & Electric Co. March 21. Attendance 31.

Modern Practise in Steam-Plant Design, by R. C. Powell, Pacific Gas & Electric Co. March 25. Attendance 50.

University of Cincinnati

High-Tension Cable and Dielectrics, by Mr. Calvert, General Electric Co. March 4. Attendance 41.

Clarkson College of Technology

Discussion of Branch activities. March 3. Attendance 21.

Colorado State Agricultural College

The Life and Experiments of Michael Faraday, by Oscar Baer, student. March 9. Attendance 9.

Film—"Dynamic America." March 16. Attendance 12.

Annual Engineers' Day held jointly with the A. S. M. E. Branch. The Influence of Gold and Silver Production on Economic Conditions, by Frank E. Shepard, Supt. U. S. Mint in Denver. March 28. Attendance 150.

Cooper Union

Magnetic Shielding of Straight D-C. Conductors, by George C. Neuschaefer and August B. Mundel, students. March 18. Attendance 12.

Cornell University

Two films shown as follows: "The Steam Turbine," and "Dynamic America." March 25. Attendance 23.

University of Detroit

Five moving pictures shown. Talks by Dean R. E. Lawrence, A. W. Mitchell, Chrysler Motor Co., and Professor F. Lysenmeyer. March 19. Attendance 210.

Harvard University

Inspection trip to the General Electric Co. at Lynn, Mass. Match 16. Attendance 25.

Iowa State College

Smoker. April 18. Attendance 140.

State University of Iowa

Film—"Conowingo." February 11. Attendance 40.

Worlds Water Power and the Hoover Dam, by W. B. Knight, student. February 18. Attendance 29.

Development of Television in the United States, by Mr. Kosek, student;

Production of Power from the Tropic Seas, by F. O. Lyddon, student. February 25. Attendance 37.

Rectifiers, by Mr. Ten Eyck, student. Film—"Dynamic America." March 4. Attendance 39.

The Mercury Vapor Turbine, by Mr. Lewis, student;

Later Applications of the Electricity in Transportation, by R. Marchant, student;

Electrical Developments in the Far East, by T. S. Mariano, student. March 11. Attendance 26.

The Cathode Ray Oscillograph, by Mr. Wilkins, student. Film—"Steam Turbine with a Solid Rotor." March 25. Attendance 39.

Kansas State College

Patents and Inventions, by Professor R. G. Kloeffler, counselor. (Afternoon session). February 18. Attendance 70.

The program of the evening session was the same as that of the afternoon session. February 18. Attendance 30.

Talk by E. D. Bell, United Power & Light Corp. (Afternoon session). March 5. Attendance 75.

The program of the evening session was the same as that of the afternoon session. March 5. Attendance 35.

Lehigh University

Psychology of Illumination, by J. B. Sponsler, student;

The Engineer in College and Out, by A. J. Standing, Bethlehem Steel Co. February 18. Attendance 43.

Audible Light, by John B. Taylor, General Electric Co. February 23. Attendance 250.

Talking Movies, by D. C. McGalliard, Electrical Research Products, Inc. March 4. Attendance 250.

Three films were shown: "Steam Turbine with a Solid Rotor," "Mechanized Mine of the Butler Coal Company," and "Dynamic America." March 20. Attendance 154.

Marquette University

Executive Board meeting. March 3. Attendance 8.

Inductance, by Mr. Forman, Louis Allis Manufacturing Co. Election of officers as follows: Ellsworth Ziehm, chairman; Anthony Cain, vice-chairman; Donald Boehmer, Secretary; Robert Manion, treasurer. March 5. Attendance 27.

Massachusetts Institute of Technology

Super-Power Production, by Francis D. Weeks, student;

Power Factor Correction and the Fynn-Weichsel Motor, by Gordon S. Brown and John C. Gibson, students. March 17. Attendance 57.

Inspection trip to the Woburn Station of the Edison Electric Illuminating Co. of Boston, and the Tewksbury substation of the New England Power Association. April 1. Attendance 17.

Michigan College of Mining and Technology

Electric Lighting, by Paul Junttila, student;

Gerald Warrener, Ontanogan Power Project, outlined in detail the routine to be followed in putting up a transmission line. March 11. Attendance 26.

Michigan State College

The Change-Over from 30 to 60 Cycles in Grand Rapids, Michigan, by H. L. Abrahamse, student;

Summer Experiences with the General Electric Company, by R. B. McCall and L. Switzgable, students. March 10. Attendance 23.

University of Michigan

Three students outlined their experiences during summer employment. March 4. Attendance 30.

Mississippi A. & M. College

Finances of American Utilities and Some Peculiar Uses of Electricity, by W. P. Gearhiser, student;

Supernatural Power, Inc., by P. W. Godard, student. March 13. Attendance 24.

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. March 24. Attendance 31.

Missouri School of Mines and Metallurgy

J. D. Roy, student, outlined student courses given by the Westinghouse Elec. & Mfg. Co. March 11. Attendance 18.

St. Pat's Electrical Show. March 21. Attendance 437.

Engineering Achievements of 1930, by J. E. Stokes and J. D. Shelton, students. Professor I. H. Lovett, counselor, gave a talk on the construction of Bagnell Dam. April 1. Attendance 20.

Montana State College

Cut-Out Designs for Street-Lighting Circuits, taken from *General Electric Review*, presented by Wesley C. Funk, student;

Electric Power in the Lumber Industry, by Jean Smith, student;

Treating Poles, taken from *Western Electric News*, presented by Carl Wall, student. Film—"Arc Welding." March 19. Attendance 151.

University of Nebraska

R. A. Richardson, Program Service Company, outlined problems encountered with the telephone radio and gave solutions to many of these problems. March 11. Attendance 39.

University of Nevada

Modern Radio Stations and Transmitting Equipment, by Mr. Knapp, student. February 25. Attendance 11.

Geophysical Prospecting, by Professor Clark Amens. March 4. Attendance 19.

Electric Power in Connection with the Lumber Industry, by Chester Elliott, student;

New Developments in Photoelectric Cells, by E. H. Tucker, student. March 11. Attendance 12.

Film—"The Single Ridge." March 18. Attendance 23.

Newark College of Engineering

Joint meeting with Rutgers University Branch. Inspection trip through Newark College of Engineering Laboratories. Address of welcome by President A. R. Cullimore, Newark College of Engineering. Short address by Dean P. H. Daggett, Rutgers University. Mr. Whitmore, Fox Film Corp., presented a talk on Making Movietone Pictures. March 9. Attendance 66.

University of New Hampshire

Advantages and Disadvantages of A. I. E. E., by F. Perkins, student;

Suggestions for Improvement of A. I. E. E., by J. Carlen, student;

Membership in A. I. E. E., by R. Williams, student. March 7. Attendance 33.

Election of officers as follows: P. A. Rolfe, chairman; R. H. Williams, Secretary. Film—"Blasting the Water Highways of America." April 1. Attendance 31.

University of New Mexico

The Life of Michael Faraday, by C. E. Henderson, Branch chairman. Election of officers as follows: M. Austin True, chairman; E. W. Huffman, vice-chairman; Stanley O. Fish, secretary-treasurer. April 2. Attendance 11.

College of the City of New York

Film—"Steam Turbine with a Solid Rotor." March 12. Attendance 35.

New York University

Power-Factor Correction, by L. F. Anderson, student;

Operation and Application of the Cathode Ray Oscillograph, by A. E. Bell, student;

Acoustics of Auditoriums, by M. Bogstahl, student. February 16. Attendance 18.

Business meeting. March 2. Attendance 18.

Cooperative Courses, by G. J. Helis, student;

The Mercury Arc Rectifier, by O. M. Lerz, student. March 16. Attendance 17.

Color in the Talkies, by C. Papini, student;

New York City West Side Development, by J. B. McNally, student;

History of Petroleum, by S. Podowitz, student;

Foreign Jobs, by G. J. McGillivray, student. March 30. Attendance 18.

North Carolina State College

Life of Joseph Henry, by L. C. Hubbard, student. March 31. Attendance 34.

North Dakota State College

Engineering and Education, by R. V. Wright, president, American Society of Mechanical Engineers. Joint meeting with the A. S. M. E. Branch. March 30. Attendance 55.

Film—"The Single Ridge." April 1. Attendance 60.

University of North Dakota

Informal talk by Professor D. R. Jenkins. April 1. Attendance 11.

Northeastern University

Traffic Control, by O. M. Jacobi, Submarine Signal Corp. Joint meeting with A. S. M. E. Branch. February 24. Attendance 50.

University of Notre Dame

Transatlantic Telephone Communication, by A. M. Rose, American Tel. & Tel. Co. Patrick Murray, student, presented a review of engineering new items. Joint meeting with the Notre Dame Engineers' Club. March 16. Attendance 187.

Ohio Northern University

Galileo's Life, by Mr. Jacobs, student. April 2. Attendance 14.

Ohio University

What Constitutes an Education?, by E. W. Chubb, Dean of the College of Liberal Arts. Report of the Middle Eastern District Meeting given by Harold Swagart, student. April 1. Attendance 19.

Oklahoma A. & M. Colleg

Rural Electrification, by Don Heffner, student. February 26. Attendance 26.

History of the Electrical Industry and George Westinghouse's Developments, by Mr. Hammond, Westinghouse Elec. & Mfg. Co. March 12. Attendance 41.

A film was presented showing the developments in the oil industry in Oklahoma. Joint meeting with the A. S. M. E., A. S. C. E., and Chemical Engineers. March 26. Attendance 150.

Under Water Cables, by Paul Warren, student. April 9. Attendance 15.

University of Oklahoma

The Life of Michael Faraday, by Roy J. Thompson, student. February 19. Attendance 33.

Maintenance of High-Voltage Lines While in Operation, by Mr. Steele, Oklahoma Gas & Electric Co.;

The Hoover Dam, by Charles Ludwick, student. March 26. Attendance 35.

Oregon State College

A Biography of Michael Faraday, by Elliott MacCracken, student;

Joseph Henry, by Alton Everest, student. March 31. Attendance 39.

Long Distance Telephone Circuit Facilities, by A. K. Morehouse, Pacific Tel. & Tel. Co. April 7. Attendance 42.

Pennsylvania Stat College

Film—"Atomic Hydrogen Welding." January 13. Attendance 132.

Inspection trip. April 11. Attendance 72.

University of Pennsylvania

Discussion of Branch activities. March 5. Attendance 20.

Talk by Professor C. D. Fawcett, counselor. Election of officers as follows: C. N. Maxfield, chairman; W. S. Caldwell, vice-chairman; H. D. Sarkis, secretary; W. H. Young, treasurer. March 23. Attendance 24.

Pratt Institute

Fourth Annual Convention held jointly with the A. S. M. E. and the Wohler Chemical Society. In the afternoon, three papers were presented by students, as follows:

History of Chromium, by L. K. Teubner;

Manufacture of Mazda Lamps, by S. P. Terni;

Principles of Operation of the Linotype, by N. W. Mackenzie.

In the evening the following talks were presented:

Brief addresses, by Dr. S. S. Edmands, Director School of Science & Technology, Ernest Hartford, assistant secy., A. S. M. E., and H. H. Henline, assistant national secy., A. I. E. E.

Our Nation's Health, by Ralph O. Clock, Davis & Geck Co.;

Television, by P. B. Smith, New York Telephone Co. March 25. Attendance 300.

Rensselaer Polytechnic Institute

Stability of Interconnected Systems, by W. E. Mayott, student. Illustrated. March 10. Attendance 150.

How Telephone Communication Serves Modern Business, by B. K. Rhodes, New York Telephone Co. Films—"The Telephone Family," and "The Flying Telephone." The following officers were elected: J. J. Lewis, chairman; F. S. Claassen, vice-chairman; H. A. Schlieder, secretary-treasurer. April 7. Attendance 180.

Rhode Island State College

The Nature of an Engineer's Work with a Public Utility, by D. Daly and J. Knapp, Blackstone Valley Light and Power Association. March 12. Attendance 22.

Business meeting. March 26. Attendance 13.

University of South Carolina

The Hoover Dam, by Charles O. Warren, student;

To Europe Via the North Pole, by J. J. Duffie, student. March 16. Attendance 29.

South Dakota School of Mines

Film—"Steam Turbines." March 10. Attendance 95.

Almon Bjerke elected chairman for next term. March 20. Attendance 32.

University of Southern California

Joint meeting with the Los Angeles Section and the California Institute of Technology Branch, at which six papers were presented by students. (See report under Past Section meetings.)

Southern Methodist University

Electronic Theory and Its Application, by Robert M. Kennedy, Southwestern Bell Telephone Co. Talk and demonstration of a 3.5 meter radio receiver and transmitter by D. J. Tucker, student. F. H. Gable, Branch Chairman, described the new radio station at the university. January 21. Attendance 36.

Description of the new 7½-watt amateur radio station W5 QG of S. M. U., operating on 20 meters, by F. H. Gable, Branch chairman. March 18. Attendance 20.

Stevens Institute of Technology

The Accurate Comparison of Frequencies by Means of the Low-Voltage Cathode Ray Tube, by F. L. Fuller, Branch secretary. March 17. Attendance 20.

Syracuse University

The Life of Faraday, by George Cowell, student;

The Life of Henry, by Paul Greiner, student. March 13. Attendance 24.

The Engineer Five Years After Graduation, by Mr. Pratt, The Niagara & Hudson Power Co. April 10. Attendance 26.

University of Tennessee

Electricity, Past, Present and Future, by C. M. Ripley, General Electric Co. March 12. Attendance 133.

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, vice-president, District No. 4, A. I. E. E. March 27. Attendance 25.

University of Texas

The Overhead Distribution System of the Austin Power Plant, by J. H. Dunaway, student. February 26. Attendance 14.

The North Austin Substation, by H. J. Adams, student;

The East Austin Substation, by J. H. Neidert, student. March 12. Attendance 11.

University of Vermont

Hollow-Spun Concrete Poles, by M. Ciardelli, student;

Measurement of Frequency of Radio Transmitters, by J. J. Hay, student. March 10. Attendance 23.

Short business meeting. Life and Work of Michael Faraday, by E. S. Judkins, student;

Life of Henry, by E. E. Whitney, student;

A description of Faraday's generator was given by Professor R. O. Buchanan. March 24. Attendance 21.

Virginia Military Institute

Film—"Assembly of Ford Cars." March 19. Attendance 49.

Three films were shown: "The Busy Body," "Carboloy," and "The Wings of the Army." April 2. Attendance 50.

Virginia Polytechnic Institute

Films—"Steam Turbine with a Solid Rotor," and "Dynamic America." April 9. Attendance 255.

University of Washington

Film—"Nature's Frozen Credits." February 5. Attendance 34.

The Centralia Power Project, by B. T. Travis, City Light and Fixture Co. February 19. Attendance 26.

The Impulse Generator, by Herbert N. Steen, student. February 26. Attendance 10.

Life of Michael Faraday, by James A. White, student. April 2. Attendance 8.

Washington State College

Business meeting. February 10. Attendance 20.

Cushman Power Project, by Mr. Backemole, student. March 5. Attendance 23.

Films—"King of the Rails" and "The Cascade Tunnel." March 12. Attendance 43.

Washington University

Business meeting. April 2. Attendance 14.

West Virginia University

The following talks were presented by students:

Propagation of Radio Waves, by A. W. Friend;

Building a Substation, by F. E. Watson;

Use of Paper in Electrical Apparatus, by W. N. Engle;

Electric Control Permits Two Elevators in One Shaft, by E. D. Harris;

Construction of the Radio Vacuum Tube, by W. P. McCue;

$28,000,000 Rock Island Hydroelectric Development, by G. H. LeFevre. March 3. Attendance 32.

The following talks were presented by students:

Reducing Transformer Failures Due to Lightning, by C. J. McCormick;

Electrification of the C. M. & St. Paul Railway, by C. F. Stewart;

Power Distribution in Belgium, by K. D. Moss;

Use of Instrument Transformers, by P. Shaff;

Effect of Temperature on Properties of Steel, by T. E. Palmer;

Modern Methods of Emptying Grain Cars, by J. N. Simpson. March 10. Attendance 31.

The following talks were presented by students:

Hydrogen-Cooled Turbine Generators, by C. E. Higgins;

Gas Electric Bus, by C. B. Withers;

Grain Cars Unloaded in Six Minutes, by P. N. Vanney;

Two Elevators in One Shaft, by D. C. Kennedy;

Hydrogen Cooling for Large Generators, by W. C. McMillion;

D-C. Transmission, by H. E. Kerwin. March 17. Attendance 33.

The following talks were presented by students:

Method of Cleaning Coal Gas, by H. A. Lewis;

Electrical Advertising, by R. W. Blair;

Electrically-Heated Garden Plot, by M. L. Sprigg;

Westinghouse Commercial Test Course, by E. D. Harris;

Diesel Electric Locomotive, by C. J. O'Leary. March 24. Attendance 32.

University of Wisconsin

Three films shown as follows: "Building New York's Newest Subway," "Driving the Cascade Tunnel," and "Hydroelectric Power Production." March 25. Attendance 95.

Worcester Polytechnic Institute

Inspection trip through the New England Telephone & Telegraph Company. March 9. Attendance 40.

University of Wyoming

Business meeting. March 3. Attendance 12.

Yale University

The Muscle Shoals Project, by J. N. Buckwalter, student;

Effect of Lightning Voltages on Rotating Machinery, by D. B. Fisk, student;

The Electron Tube and Its Application to Industry, by R. C. Schlitt, student. March 12. Attendance 13.

During the week of March 25th to April 2nd, the engineering seniors went on the annual inspection trip. Attendance 90.

Public Speaking, by Professor Hubert Greaves. Illustrated. April 9. Attendance 29.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

GRADUATE of five-year cooperative school in electrical engineering; speaks Spanish and English fluently; one year study of production methods and five years' of street railway experience. Desires position in any state or nation. Location, immaterial. Age 24. C-9002.

COLLEGE GRADUATE class of 29, B. S. degree in electrical engineering, 25, single. General Electric Test, general engineering and business courses. Interested in position in engineering department of manufacturing or utility company. Available at once. Location, eastern states. C-9003.

1928 GRADUATE ELECTRICAL ENGINEER, 26, married. One year G. E. Test; one year transformer engineering design, six months' railway signaling. Desires position with railway, power, or manufacturing company. Available on short notice. Location, immaterial. C-9001.

GRADUATE ELECTRICAL ENGINEER, 35, experienced large prominent electrical manufacturer, test course, sales and engineering departments, quotation, design, research, dedevelopment, factory engineering supervision, technical reports. Investigation materials, power-factor correction problems and distribution systems. Transformers, motors, generators, switchboards, etc. Desires position, design, sales, consulting, engineering, general technician. Location preferred, east, south. C-7321.

1929 GRADUATE ELECTRICAL ENGINEER, age 24; 15 months of General Electric Test course and first year of advanced engineering course. Now taking graduate work at Harvard Engineering school. Desires position with a future. Location preferred, Cleveland, Ohio. Available in June. C-8979.

ELECTRICAL ENGINEER, E. E. degree, 26, single. General Electric Test course, public utility test experience. Two years' experience sound picture industry. Interested in position with manufacturing company or public utility. Available at once. C-4810.

ELECTRICAL ENGINEER, 30, single, technical graduate, G. E. Test, 10 years design and construction of substations, power plants, electrical railways and mines, 5 years foreign. Desires position as engineer or general foreman. Location, anywhere. Available at once. C-217.

GRADUATE ELECTRICAL ENGINEER, 28, four years' manufacturing experience in production and engineering on electrical motors. Desires position with company where greater opportunities are offered. C-2882.

GRADUATE ELECTRICAL ENGINEER, 35, good technical school. Ten years' experience in electrical station construction and design drafting, including considerable mechanical experience. Latest position superintendent of design and construction of transformer substation. Prefers station design and construction with utility, would consider engineering industrial plant maintenance or operation. C-7043.

GRADUATE ELECTRICAL ENGINEER, 25. Three years electrical test engineer, public utility company. One and one-half years electrical design engineer resistor control devices. Desires electrical engineering position with definite future opportunities. Prefers development and design of signal apparatus. Available immediately. Location preferred, Metropolitan New York, but will consider others. C-8999.

ELECTRICAL ENGINEER, age 28; single, considerable industrial experience; one year as graduate assistant; M. S., Iowa State College, 1930; B. S., Pennsylvania State College, 1925. Desires position as instructor, with the prospect of a permanent teaching position. C-3202.

ELECTRICAL ENGINEER, university graduate, 36, married. Background of eight years' experience electrical testing in field and laboratory. Additional 3½ years' experience in testing and manufacture of radio tubes. Desires position as test engineer with radio tube manufacturer. Location preferred, Metropolitan New York. Available now. B-8817.

ENGINEER, E. E. 1926 Ga. Tech. Age 29, married. Several months drafting with Georgia Power Company. Five years' experience in large sugar mill in Cuba. Four years as chief electrician. Working knowledge of Spanish. C-9027.

1931 ELECTRICAL GRADUATE, single, 23, available immediately. Will receive diploma from Texas University in June. Desires any engineering work with opportunity to advance. Has had experience in bookkeeping and typing. C-9019.

ELECTRICAL AND ILLUMINATING ENGINEER, B. S. and E. E. degree, 31, married. Two years' experience with incandescent lamps. Two years designing motor controllers and pilot switches for large machine tools. Seven years' experience with designing motor starters, speed regulators, resistance specialities, theater dimmers, flood-lighting and window lighting control. Location preferred, New York or California. B-4850.

ELECTRICAL ENGINEER, recent graduate, desires a position in the East with an electrical contractor or with a manufacturing concern for production. C-8975.

GRADUATE ELECTRICAL ENGINEER, single, two years' experience on factory apprenticeship course, electrical and mechanical testing, five years sales engineer in wire and cable industry, four years industrial selling. Desires position as sales engineer or commercial and power sales work with a utility. Location preferred, Eastern United States. B-6002.

COLLEGE GRADUATE, 23, single, B. S. in E. E. in 1929. Eighteen months' experience with service department public utility. Desires position in any electrical line with future and opportunity for advancement. References. Available at once. C-9034.

GRADUATE ELECTRICAL ENGINEER, Columbia University, 1906. Age 45. Twenty-five years' experience with design and general engineering problems of steam-electric generating stations and distribution substations. Desires position as electrical engineer with public utility company or engineering firm. A-5466.

DEVELOPMENT AND RESEARCH ENGINEER, M. E., E. E. with considerable experience and successful record with intricate electromechanical problems involving theory and mathematics, high designing and supervising skill. Radio-frequency circuits and measuring instruments. Remote control and public-address systems. Position desired in New York City. A-165.

SENIOR ELECTRICAL ENGINEERING STUDENT, 23, wishes appropriate opening in electrical industry; manufacturing, test or operating. Best references. Location, immaterial. Available June 22nd. C-9084.

ELECTRICAL ENGINEER, 1930, age 31, single, U. S. citizen. Graduate from an engineering college of a "big-ten" university. Telephone and machine shop experience. Speaks Greek besides English. Wishes permanent position in any engineering field. Location, immaterial, go abroad. C-9075.

UTILITIES ASSISTANT EXECUTIVE or local manager. Trained mechanical, electrical, and refrigerating engineering. Experienced operating, construction, engineering, management, public relations, selling, general business administration, accounting. Most valuable to organization desiring to effect maximum economy operating moderate sized property or division larger property. Now engaged, own business. Willing to prove value to employer, salary moderate to start. C-9050.

ELECTRICAL ENGINEER, married, with 20 years' electric utility operating experience in engineering, construction, maintenance of distribution and transmission lines. Substations, first-aid and educational work. Experience in solving radio interference problems. Can qualify as electrical superintendent or assistant to manager. Proved record of qualifications. C-7700.

GRADUATE ELECTRICAL ENGINEER, B. S. degre 1928, single, age 25. Two years' electrical distribution experience; one year of research work. Desires position with a public utility or manufacturing concern. Willing to start at bottom of any work with a future. Available on short notice. Location preferred, Eastern United States. C-7341.

TECHNICAL GRADUATE desires position with public utility. Twelve years' experience on overhead transmission and distribution, design, estimates, field checks, etc. Age 37, married. B-9248.

ELECTRICAL AND RADIO ENGINEER, four years' experience in research and development. Designing, constructing, servicing, and experimenting with radio circuits, amplifiers, vacuum tubes, and sound recording. Three years with research bureau of power company. Testing, checking, and calibrating laboratory instruments, relays, station apparatus. Prefers New York or vicinity. C-3087.

ELECTRICAL ENGINEER, 1928 graduate of a recognized university, 26, single. One year public utility experience, 1½ years as special apprentice on large electrified railroad. Available on short notice. C-9112.

ELECTRICAL ENGINEER, 34 years old, with extensive machine-shop experience in production and maintenance; also power house, and machine designing. Graduate of Cooper Union Institute of Technology. Willing to go anywhere. Good reference. C-1360.

SWITCHBOARD ENGINEER, age 30, single, American citizen, German college education. Six years practical electrician. Five years with Westinghouse Electric and Railway Supply Co. Thoroughly familiar with design, layout and construction of slate and steel panels. Expert in wiring diagrams; power and control circuits, relay applications and metering schemes. C-9037.

PROFESSOR OF ELECTRICAL ENGINEERING, 32, married, B. S. (E. E.) and E. E., three years with General Electric Company, five years with public utility, four years' teaching and administrative experience in state university. Excellent references. Available for next academic year. Correspondence invited. C-7152.

ELECTRICAL ENGINEER, 1930, B. S. in E. E., 24 years old, desires connection, any kind of work except sales or radio. Location, immaterial. C-9105.

GRADUATE ELECTRICAL ENGINEER, age 28, married, 8 years of industrial control, power plant design, and construction supervision experience with contractor. Desires position with public utility or manufacturing concern's engineering or construction departments. Location desired, Middle West. C-4428.

ENGINEER, age 42, electrical wiring layouts for industrial plants and buildings of a large variety for engineers, contractors and architects; also experienced in construction and operation. Location desired, New York City or Northern New Jersey. B-5068.

GRADUATE ELECTRICAL ENGINEER, 25, B. S. degree '29. Nineteen months' experience on general electric test, including 8 months as assistant foreman and foreman of power mercury arc rectifier test. Desires connection with operating or construction company in East or Middle West. C-9089.

ELECTRICAL ENGINEER, graduate, 33, married, 13 years' office and field experience design and construction power plants, substations, distribution systems, industrial electrifications, etc. Familiar with motors and control; some steam experience. Six years in Latin-America in positions of responsibility; fluent Spanish. Used to handling men. Seeks permanent connection in U. S. A. C-8553.

ELECTRICAL DESIGN DRAFTSMAN OR CHECKER, age 31, single, fourteen years' experience on power plant, high- and low-voltage substation and automatic railway substation design. Equivalent of college education. Available immediately. Location, immaterial. B-8628.

PROFESSOR OF ELECTRICAL ENGINEERING, Ph. D., wishes position as head of department of electrical engineering in a growing institution. Excellent general electrical engineering teaching and practical experience. B-660.

GRADUATE ELECTRICAL ENGINEER, 31, single, 8 years' experience, design and construction of transmission lines, voltages up to and including 220 kv., outdoor and indoor high-voltage substation and distribution networks. Desires position in engineering or construction department of large utility or holding company. Location, immaterial. C-3564.

ELECTRICAL ENGINEER, 28. Nine years' varied experience with power and communications companies. Successful design and supervision of experimental apparatus construction. Special transmission work with network and cables. A-c. measurements, high-voltage test, telephone plant work. Graduate Georgia Technology cooperative course. Location, preferred, New York or vicinity. C-9044.

GRADUATE ELECTRICAL ENGINEER, of Purdue University with 18 years' experience in design, construction, estimating, costs, valuation and appraisal of power plants, substations, transmission lines and industrial plants including five years in heavy electric traction and rapid transit work. Open for opportunity with future. C-8256.

SALES ENGINEER, electric specialties; experience in utilities engineering, also illumination and fixture manufacture. Available with two weeks' notice. Salary or commission. C-2942.

ELECTRICAL ENGINEERING GRADUATE, experienced in sales, contact, lecturing and promotion work. Desires position as representative along utility or heavy-duty industrial equipment lines. Location, Eastern preferred. B-4067.

1929 GRADUATE, E. E., age 23, married One year experimental work on steam turbines, half year laboratory assistant to research engineer of electric manufacturing company. At present unemployed. Location, immaterial. C-9132.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility, and industrial surveys covering: cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense and cost analysis. Capable organizer. Profitable assistant to busy executive. Prefers East. Consider any proposition. B-9122.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St. San Francisco N. D. Cook, Manager	205 West Wacker Drive Chicago A. K. Krauser, Manager	31 West 39th St. New York W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

RECENT GRADUATE ELECTRICAL ENGINEER, single, age 25. Desires engineering work. Has had experience in drafting. Location, United States or foreign. Available immediately. C-8437.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, 24, married, excellent physical condition. One year's experience in electric-shovel construction. Desires position with future. Location and salary immaterial. Best of references. Available at once. C-9142.

MECHANICAL - ELECTRICAL ENGINEER, American, 37 years old, six years in charge of factory manufacturing 700 tons of raw sugar daily, factory employing 250 men. Has done considerable original work in welding. Capable of supervision of the design, layout, construction of plants handling large tonnage. C-9052.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, age 25 and single. Experienced in machine-shop and steel-construction work. Four years of practical and theory of electricity in college. Willing to start at the bottom and work up with a reliable company. Available at any time. Location anywhere in United States. C-9135.

GRADUATE ELECTRICAL ENGINEER, 24, two years' manufacturing experience. Desires position on university staff with opportunity to work on Master's degree. Available September. C-9157.

1931 GRADUATE ENGINEER, single, age 24. B. S. in E. E. from University of Kansas in June. Prefers junior engineer work in public utility or manufacturing concern. Willing to begin at bottom where ability, productivity, and personality will produce advancement. Good student. Best of references. Available June 1931. Anything anywhere considered. C-9094.

ELECTRICAL ENGINEER, American, 40, married. Experienced in power generation, transmission, distribution and application to industrial uses. Work covers layout, constuction, operation, maintenance, and repairs. Desires position as electrical engineer with manufacturing concern generating its own power or with utility company. Speaks Spanish. Available on reasonable notice. C-502.

SWITCHBOARD FOREMAN, 10 years' experience with construction companies for public utilities, wiring, construction and installation of power house switchboards and control apparatus. Shop experience, manufacturing switchboards. C-4831.

MANAGER OR SUPERINTENDENT, 47, married. Executive, electrical or industrial. Successful organizer, fficient operator. Knows men; can handle them. Expecially interested in properties not now paying, where future depends on results. Reads, writes, speaks Spanish. Capable earning six thousand up. Available reasonably short notice. Location, not particular; prefers Western United States. C-8777-312-C-1-San Francisco.

ELECTRICAL ENGINEER, B. S. in E. E. 1930, age 25, single. Some steel mill operating experience. Now employed on G. E. test. Desires permanent position with utility company in construction, maintenance, or design work. Good references and personality. C-9159.

GRADUATE ELECTRICAL ENGINEER, 1930, single, six months on Westinghouse engineering course covering tests n switchboards, circuit breakers, regulators, motors, generators, etc. Nine months supervising telephone conduit and cable plant construction and telephone cable testing. Excellent physical condition. Desires permanent position with good future. Location, immaterial. C-9158.

ELECTRICAL ENGINEER, college graduate, 31, married. Eleven years in station, transmission, and distribution designs; system operation and planning; superintendence of meter and relay department; studies, reports and calculations. Good theoretical as well as practical background. Accustomed to responsibilities. Prefers New York or environs but will consider good proposition elsewhere. B-9401.

1930 GRADUATE ELECTRICAL ENGINEER, 23, single. Has had four months on Westinghouse Student Course and considerable industrial experience preceding graduation. Desires to connect with a public utility company. Location, immaterial. Available on two weeks' notice. Good references. C-9150.

ELECTRICAL ENGINEER, B. S. in E. E., 1927, single. Twenty months' experience in design and testing of fractional hp. motors; two years' industrial plant experience. Familiar with motors and control equipment. Desires position as lectrical engineer. Location, immaterial. C-9168.

ASSISTANT PROFESSOR OR INSTRUCTOR IN ELECTRICAL ENGINEERING, 33, married, six years' administrative and teaching experience both E. E. and M. E. subjects. Position desired with technical school in South or West where opportunity is offered for advanced study and research. Available September. C-9166.

Membership

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before May 31, 1931.

Anderson, F. E., Dept. of Public Works, State of Calif., Sacramento, Calif.
Angle, W. P., Virginia Electric & Power Co., Richmond, Va.
Archer, E. T., (Member), E. T. Archer & Co., Kansas City, Mo.
Atkinson, E. S. (Member), H. B. Sherman Mfg. Co., Battle Creek, Mich.
Beavers, M. F., General Electric Co., Pittsfield, Mass.
Becker, F. G., Electrical Trades School, Cincinnati, Ohio
Benson, C. R., General Electric Co., San Francisco, Calif.
Betz, L. G., Public Service Electric & Gas Co., Hackensack, N. J.
Blum, R. A., Buffalo General Electric Co., Buffalo, N. Y.
Brackett, C. H., Union Carbide Co., Niagara Falls, N. Y.
Brennan, J. J., Memphis Power & Light Co., Memphis, Tenn.
Browne, T. E., Jr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Bunker, F. C., (Member), General Electric Co., Houston, Tex.
Byron, T. J., New York Telephone Co., Albany, N. Y.
Cain, W. W., Consolidated Gas Co., New York, N. Y.
Cutting, F. S., (Member), 98 Carolina Ave., Providence, R. I.
Donabar, H. F., 2325 No. 50th St., Milwaukee, Wis.
Drew, C. E., (Member), R. C. A. Institute, Inc., New York, N. Y.
Duncan, R. L., (Member), R. C. A. Institute, Inc., New York, N. Y.
Durnin, E. J., Saskatchewan Power Commission, Saskatoon, Sask., Can.
Eason, R. K., General Electric Co., Beaumont, Tex.
Edwards, D. V., Electrons Inc. of Delaware, Newark, N. J.
Edwards, G. W., Cleveland Railway Co., Cleveland, Ohio
Ellis, E. A., Atlantic Electric Co., Boston, Mass.
Essington, H. M., (Member), Chicago Surface Lines, Chicago, Ill.
Findlow, C. W., Amalgamated Electric Corp., Toronto, Ont., Can.
Frank, W., 312 Fredericka St., North Tonawanda, N. Y.
Fuller, H. W., Saskatchewan Power Commission, Regina, Sask., Can.
Gallagher, D. H., Public Service Electric & Gas Co., Orange, N. J.
Garstang, W. W., P. R. Mallory & Co., Inc., Indianapolis, Ind.
Gilliatt, C. F., Toronto Hydro Electric System, Toronto, Ont., Can. (Applicant for re-election)
Gledhill, C. L., Public Service Electric & Gas Co., Newark, N. J.
Hillebrand, A. G., Spicer Mfg. Corp., Toledo, Ohio
Hogg, T. H., (Member), Hydro-electric Power Comm. of Ontario, Toronto, Ont., Can.
Horn, R. S., Raydio Ray Corp., Spokane, Wash.
Jansson, M. E., D. Van Nostrand Co., Inc., New York, N. Y.
Jenkins, R. D., Atchison, Topeka & Santa Fe Railroad, Albuquerque, New Mexico
Johanson, C. G., Jr., N. E. P. Engg. & Service Corp., Boston, Mass.
Johnson, G. W., Texas Power & Light Co., Palestine, Tex.
Krauer, O., Otis Elevator Co., Yonkers, N. Y.
Lancaster, H. W., The Bristol Co., Akron, Ohio
Lawrence, W. H., Syracuse Lighting Co., Inc., North Syracuse, N. Y.
Leavy, M., Haaren High School, New York, N. Y.
Lewis, W. P., American Steel & Wire Co., Worcester, Mass.
Lines, M. B., Mountain States Tel. & Tel. Co., Denver, Colo.
MacKenzie, N. H., United Engineers & Constructors, Newcastle Creek, N. B., Can.
MacLaughlin, R. R., American Tel. & Tel. Co., Cleveland, Ohio
Malone, D. L., Student, Delta, Pa.
Marcroft, H. C., Pennsylvania Water & Power Co., Holtwood, Pa.
Marsden, H. M., Hartford Steam Boiler Inspection & Insurance Co., New York, N. Y.
McCall, C. C., Cleveland Electric Illuminating Co., Cleveland, Ohio

McCarren, R. P., Anaconda Copper Mining Co., Anaconda, Montana
Michelsen, C. H., 4456 Douglas Rd., Toledo, Ohio
Miller, H. E., General Electric Co., Philadelphia, Pa.
Miller, R. H., (Member). 524 Liberty Bldg., Des Moines, Iowa
Morrison, A. C., Duke Power Co., Charlotte, No. Car.
Morse, J. A., New England Tel. & Tel. Co., Boston, Mass.
Nelson, J. W., Park Coal Co., Leechburg, Pa.
Nelson, L. V., Union Electric Lt. & Pr. Co., St. Louis, Mo.
Osborne, J. I., Dept. of Institutions & Agencies, Holmdel, N. J.
(Applicant for re-election)
Osterberg, E. T., Illinois Bell Telephone Co., Chicago, Ill.
Owens, F., Brooklyn Edison Co., Brooklyn, N. Y.
Pearson, D. S., General Electric Co., Erie, Pa.
Perkins, E. F., Allied Engineers, Inc., Jackson, Mich.
Perkins, W. J., General Electric Co., Philadelphia, Pa.
Persons, J. H., General Electric Co., Atlanta, Ga.
Phelan, C. S., U. S. Shipping Board, New York, N. Y.
Phillips, R. J., Scranton Electric Co., Scranton, Pa.
Port, R. F., Syracuse Lighting Co., Syracuse, N. Y.
Pullen, W. S., (Member). Alaska Electric Lt. & Pr. Co.; Juneau Ferry & Navigation Co., Juneau, Alaska.
Ranney, W. E., Washington Water Power Co., Spokane, Wash.
Rebsamen, L. M., City Water & Light Plant, Jonesboro, Ark.
Reif, W. H., The Montana Power Co., Bozeman, Montana
Robinson, L. E., Chicago Rapid Transit Co., Chicago, Ill.
Saft, A. J., N. Y. C. High Schools, New York, N. Y.
Shifrin, L. I., National Crafts Supply Co., New York, N. Y.
Simon, A. B., Jr., Senior, Purdue University, W. Lafayette, Indiana
Smith, E. F., University of Florida, Gainesville, Fla.
Stewart, W. J., N. J. Power & Light Co., Holland, N. J.
Taylor, E. H., Westinghouse Elec. & Mfg. Co., East Springfield, Mass.
Welch, E. S. (Member), Southern Indiana Tel. & Tel. Co., Seymour, Indiana
Williams, A. R., (Fellow), 4 Ogden Ave., White Plains, N. Y.
Young, E. W., Edison Electrical Illuminating Co. of Boston, Boston, Mass.
Zak, F. J., Virginia Electric & Power Co., Richmond, Va.
Total 84

Foreign

Ganguli, A. K., E. I. Railway, Allahabad, India
Hill, J. B., Pernambuco Tramways & Power Co., Ltd., Pernambuco, Brazil, So. America
Minocha, K. R., International General Electric Co., Ltd., Lahore, India
Nath, N., Principal Service Electrical Engg. College, Rawalpindi, India
Pritchard, A. C., H. M. Prison Commissioners, Walton, Liverpool, England
Total 5

Transfers

Recommended

The Institute's board of examiners at its meeting of March 25, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

McNEELY, JOHN K., professor of elec. engg., Iowa State College, Ames, Iowa.
PETURA, FRANK J., general purchasing engr., Henry L. Doherty & Co., New York.
REID, HARRY, president, Electric Management & Engineering Corp., New York.

To Grade of Member

ALMQUIST, MILTON L., telephone engr., American Tel. & Tel. Co., New York.
BAILEY, JULIAN C., general engr., Columbia Engg. & Mgt. Corp., Cincinnati, Ohio.
BARNES, MARION S., sales agent, General Electric Co., San Francisco, Calif.
CANFIELD, DONALD T., asst. professor of elec. engg., Purdue University, Lafayette, Indiana.
CASEY, EDWARD A., district engr., Anaconda Wire & Cable Co., New York.
CASSELL, RAYMOND L., asst. to president, W. S. Lee Engineering Corp., New York.
CHAMPREUX, ALFRED J., transmission and protection engr., Pacific Tel. & Tel. Co., Seattle, Wash.
COFFIN, JOHN R., engr., Jackson & Moreland, Boston, Mass.
COPELAND, MARK W., Voorhees, Gmelin & Walker, New York.
DIEFENDERFER, JOHN H., asst. to supt. of distribution, Pennsylvania Power & Light Co., Hazleton, Pa.
FARNHAM, WILLIAM E., local traffic engineer, American Tel. & Tel. Co., New York.
FAWCETT, ORVILLE E., maintenance engr., West Penn Power Co., Pittsburgh, Pa.
FOERSTER, JOHN A., general electrical supt., City Hall, Prince Albert, Sask., Canada.
FRANK, AUGUSTUS A., chief engineer, N. Y. Telephone Co., New York.
GORHAM, ROBERT C., asst. prof. of elec. engg., University of Pittsburgh, Pittsburgh, Pa.
GRISWOLD, DEMETRIUS W., manager and chief engr., The British Plaster Board Ltd., Cheshire, England.
KENT, HARRY E., asst. engr., National Electric Light Association, New York.
LANE, FREDERIC ALLEN, electrical engr., American Gas & Electric Co., New York.
LITTLE, THOMAS J., manager, transmission sales dept., Anaconda Wire & Cable Co., New York.
PARKER, CARLETON H., asst. line signal supervisor, United Electric Railways Co., Providence, R. I.
RODRIGUEZ, RODOLFO CID, chief electrical engr., National Railways of Mexico, Mexico, D. F.
ROYDEN, GEORGE T., division engr., Mackay Radio & Telegraph Co., San Francisco, Calif.
TOWNSEND, ARTHUR, chief inspector, Saskatchewan Power Commission, Regina, Sask., Canada.
TULLAR, CHARLES E., manager, patent dept., General Elec. Co., Schenectady, N. Y.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during March are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

AVIGATION. By Bradley Jones. N. Y., John Wiley & Sons, 1931. 314 pp., illus., diagrs., 8 x 5 in., cloth. $2.75.——A brief textbook, intended to give the aviator a practical knowledge of the subject. The instruments used, methods of computing distance and track, drift correction standard and short methods for finding position by astronomic methods, radio navigation and fog flying are discussed.

TURBINEN-SCHNELLAÜFERN, Theorie und Bau. By Viktor Kaplan and Alfred Lechner. München, R. Oldenbourg, 1931. Illus., diagrs., 10 x 7 in., cloth. 18-r. m. ——This book, which is an entirely rewritten edition of Professor Kaplan's former work, "Bau der rationellen Francis Turbinen-Laufraeder," contains an account of the practical and theoretical results of his many years of experimental work upon high-speed turbines, and of the development of the Kaplan turbine. The principles of runner design and methods of regulation are set forth and illustrated by actual installations. Professor Lechner presents a summary of the hydromechanical investigations that have interest to the turbine designer, and a statement of turbine theory.

SYMPOSIUM ON AIRCRAFT MATERIALS. American Society for Testing Materials. Phila., 1930. 192 pp., illus., diagrs., 9 x 6 in., cloth. Price not indicated.——Contains eighteen papers by various engineers discussing matters of metals, alloys, woods and textiles used in constructing aircraft, aircraft finishes, the use of stampings and castings, failures of engine parts, specifications, mechanical and X-ray testing, welding procedure and heat treatment.

INDUSTRIAL ACCIDENT PREVENTION; a Scientific Approach. By H. W. Heinrich. N. Y., McGraw-Hill Book Co., 1931. 366 pp., illus., tables, 8 x 6 in., cloth. $4.00.——A very thorough presentation of the essential principles of accident prevention, based upon long practical experience. The author describes, step by step. the procedure for determining the causes of accidents, the selection and application of the remedy, safety psychology, etc. Many good methods of guarding machinery are shown.

AMERICAN DIESEL ENGINES. By L. H. Morrison. N. Y., McGraw-Hill Book Company, 1931. 606 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.——This book will interest the prospective purchaser and the operating engineer. It discusses comparative costs of Diesel and steam plants, the operation and adjustment of Diesel engines and their suitability for various kinds of work. It also gives descriptions of engines being made at present in this country, and parts.

STANDARD FOUR-FIGURE MATHEMATICAL TABLES. 2 vols. (1 vol., Edition A; 1 vol., Edition B). By L. M. Milne-Thomson and L. J. Comrie. Lond. & N. Y., Macmillan Co., 1931. 245 pp. each vol., diagrs., 11 x 8 in., cloth. $4.50 each vol.——This work is intended to provide a comprehensive table of the numerical values of the elementary functions that are in constant use in the applications of mathematics in physics, engineering, statistics, etc. It includes a number of tables on trigonometrical functions with the argument in radians, hyperbolic functions, inverse trigonometrical and hyperbolic functions, natural logarithms and powers of *e*. Edition A has positive characteristics in the logarithms; edition B, negative characteristics

RELAYS IN AUTOMATIC TELEPHONY; Their Construction, Design and Adjustment, together with the Theory of Impulsing and the Measurement of Time Lags. By R. W. Palmer. N. Y., Isaac Pitman & Sons, 1930. 192 pp., illus., diagrs., 7 x 5 in., cloth. $3.00.——A textbook in which the subject is explained clearly and simply.

QUALITATIVE CHEMICAL ANALYSIS. By Herman T. Briscoe. N. Y., D. Van Nostrand Co., 1931. 279 pp., diagrs., 9 x 6 in., cloth. $2.25.——A comprehensive treatment of the subject, intended for students with some knowledge of general chemistry. The first half of the book presents the theories and principles of electrolytic solutions and the properties of the various anions and cations which are involved in the analytical procedures. The second half gives a practical laboratory course.

ORGANIZATION ENGINEERING. By Henry Dennison. N. Y., McGraw-Hill Book Co., 1931. 204 pp., 8 x 5 in., cloth. $2.00.——This book discusses the problems of group action and points out some of the conditions necessary for effective organization work. The characteristics of human nature are surveyed, methods for guiding and increasing joint productivity considered, and the principles of organization structure set forth.

ILLUMINATING ENGINEERING EQUIPMENT, THEORY AND DESIGN. By L. B. W. Jolley, J. M. Waldram and G. H. Wilson. N. Y., John Wiley & Sons, 1931. 709 pp., illus., diagrs., tables, 10 x 6 in., cloth. $12.00.——Starting with an account of the fundamental principles of illumination, the authors next describe the varieties of electric lamps used as sources of light, and then take up the question of lighting equipment. This topic is the major one of the book and is treated at length. The types of equipment for various purposes; their mechanical design; reflecting, diffusing and refracting media; projecting systems; color media; and equipment for the stage, advertising, studios, etc. are discussed. A section is also devoted to auxiliary equipment. Of use to everyone interested in the selection of equipment.

COMMUTATRICES ET CONVERTISSEURS ROTATIFS. By M. Barrère. Paris, J. B. Baillière et Fils, 1931. Illus., diagrs., 9 x 6 in., paper. (No price given).——A practical textbook upon the theory and design of rotary converters.

COMMUNICATION NETWORKS, v. 1; Classical Theory of lumped constant networks. By Ernst A. Guillemin. N. Y. John Wiley & Sons, 1931. 425 pp., diagrs., 9 x 6 in., cloth. $5.00.——Existing texts on the principles of communication, the author states, deal with the theory and practical significance of special types of networks commonly used in radio or telephone circuits. In the present book an attempt is made to take a broader view, by considering matters that are not of direct practical use, and thus to give the student a more thorough grasp of the fundamental methods of attack upon network problems in general. A succeeding volume on the theory of lines, cables and filters will appear next fall.

BARLOW'S TABLES OF SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS AND RECIPROCALS of all Integer Numbers up to 10,000. 3rd edition, edited by L. J. Comrie. London, E. & F. N. Spon, 1930. 208 pp., 9 x 6 in., cloth. 7/6.——For 90 years Barlow's Tables have been printed from the plates prepared for De Morgan's edition of 1840. The present edition is reset from modern type, and advantage taken of the opportunity to restore certain tables omitted from the second edition, some valuable new ones added, and certain other improvements effected.

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

	(May 1931) Number	Author	Title
☐	31-12	J. W. Milnor and G. A. Randal	The Newfoundland-Azores High-Speed Duplex Cable
☐	31-36	J. H. Ashbaugh	Automatic Regulators in Industries
☐	31-44	R. N. Southgate, A. S. Brookes, E. R. Whitehead and W. G. Roman	Impulse Tests on Substations
☐	31-68	B. F. Bailey	Measurement of Noise in Electrical Machinery
☐	31-73	E. A. Bishop	Noise Mitigation in Substations
☐	31-76	E. H. Hull and W. C. Stewart	Elastic Supports for Isolating Rotating Machinery
☐	31-78	Quentin Graham, Sterling Beckwith, and Frank H. Milliken	Magnetic Noise in Synchronous Machines
☐	31-80	T.G. Castner, E. Dietze, G.T. Stanton, and R. S. Tucker	Indicating Meter for Measurement and Analysis of Noise
☐	31-81	H. B. Marvin	The Measurement of Machinery Noise
☐	31-84	J. P. Foltz and W. F. Shirk	Induction Regulator Noise

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its publication in ELECTRICAL ENGINEERING. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name...

Address...

Pleas order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Selected Items *From* Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translation of foreign articles at cost.

Arcs

ELECTRIC. Dynamisches Verhalten des Lichtbogens nach Untersuchung mit dem Kathodenoszillographen (Dynamic Behavior of Electric Arc According to Study With Cathode Ray Oscillograph), H. Klemperer. *Archiv fuer Elektrotechnik*, vol. 25, no. 1, Jan. 27, 1931, pp. 73-80, 15 figs. Purpose of study is to investigate whether arc, after elapse of 1/100,000,000 sec., already has properties of stationary arc.

Armatures

WINDINGS. Die einfache Ausfuehrung der Bruckloch-Ankerwicklungen fuer Wechselstrom (Simple Method for Design of A-C. Armature Windings), T. Seike. *Elektrotechnik und Maschinenbau*, vol. 49, no. 2, Jan. 11, 1931, pp. 21-29, 13 figs. Simplified method for laying out of a-c. windings in which number of slots per pole and phase contains fractional value; method is developed for three-phase windings but can equally well be applied to single phase windings.

Atmospheric Electricity

MEASUREMENTS. Ueber die Messmethoden der elektrischen Leitfaehigkeit der Atmosphaere (Measuring Methods for Electric Conductivity of Atmosphere), J. Scholz. *Physikalische Zeit.*, vol. 32, no. 3, Feb. 1, 1931, pp. 130-139, 4 figs. Two sensitive apparatus were used to exclude meteorologic influences; it was shown that in comparative measurements, if possible, determination of potential gradient with radioactive sounding equipment should take place at great distance from location of observation, as deviations of over 100 per cent were often noticed.

Cables

FAULT LOCATION. Finding Cable Sheath Faults, J. Erickson. *Elec. World*, vol. 97, no. 9, Feb. 28, 1931, p. 409, 1 fig. Simple method, that makes use of only 6-volt battery, galvanometer and length of wire, has been found to be unusually accurate in locating conductor-to-sheath faults in lead-covered parkway cable on series street lighting systems.

INDUCTANCE. The Inductance Coefficients of a Part of a Circuit, and Their Applications, A. Russell. *Inst. Elec. Engrs.—Jl.*, vol. 69, no. 410, Feb. 1931, pp. 270-280, 9 figs. Theoretical mathematical study applied to electric cables and their sheath losses.

INSULATING MATERIALS. Cable Terminal Box Compounds, E. Woodrow. *Elec. Engr. Australia and New Zealand*, vol. 7, no. 10, Jan. 15, 1931, pp. 355-358, 1 fig. Defects that arise in insulating compounds and properties that are required; characteristics of what is considered ideal compound, and methods used and precautions to be taken in filling terminal box with such compound.

LEAD SHEATHING. Lead Sheaths for Cables, N. A. Allen. *Elec. Rev.*, vol. 108, nos. 2777 and 2778, Feb. 13, 1931, pp. 275-276 and Feb. 20, pp. 321-322, 5 figs. Cables with pure-lead sheaths will, sooner or later fail; examples of cases where this may have been are cited; notes on lead-improving alloys; lead-antimony research.

LOSSES. Contributo Allo studio delle perdite dell'autoinduzione dei cavi unipolari armati con fili di ferro (Losses and Self Induction in Steel Armored Single-Conductor Cables), L. Bosone. *Elettrotecnica*, vol. 18, no. 1, Jan. 5, 1931, pp. 2-8, 6 figs. Distribution of magnetic field in armor and calculation of losses; diagrams and tables checked by experimental research. Bibliography.

OIL-FILLED. Oil Reservoir on Cable Joint Saves Material, O. L. Riggs. *Elec. World*, vol. 97, no. 10, Mar. 7, 1931, p. 465, 1 fig. Material and pole space may be saved in three-conductor type "H" aerial cable by mounting oil reservoir on joint itself; in this way running of long hose from pole to joint may be avoided.

Oil-Filled Cable Lines in London, C. E. G. King. *Elec. Times*, vol. 79, no. 2050, Feb. 19, 1931, pp. 231-234, 12 figs. 66,000 volt oil-filled cable of British grid system which are now in operation linking up Hammersmith, Battersea and Fulham power stations of London Power Company.

TELEPHONE. Telephone Cables—N. A. Allen. *Elecn.*, vol. 106, no. 2753, Mar. 6, 1931, pp. 360-361, 3 figs. Recent improvements in design of short distance types for subscribers' circuits.

TESTING. Earth Currents, R. N. Pegg. *Elec. Rev.*, vol. 108, no. 2779, Feb. 7, 1931, p. 370, 2 figs. Tests indicate that small currents in cable sheaths do not necessarily denote high-resistance faults.

Circuit Breakers

COMPRESSED AIR. Latest Developments in Compressed-Gas Circuit Breaker Design, O. Mayr. *AEG Progress*, vol. 7, no. 1-2, Jan.-Feb. 1931, pp. 30-32, 8 figs. Outdoor type of compressed-gas breaker up to 100-kv. working voltage and its operating characteristics.

OIL. Neuer Motorschutz-Oelschalter mit Fernbetaetigung (Novel Remote Control Protective Motor Oil Circuit Breaker), A. Cohn. *Elektrotechnische Zeit.*, vol. 52, no. 9, Feb. 26, 1931, pp. 259-260, 6 figs. AEG-MSBO equipment for 550 volts, 60 amperes is non-interlocked push-button control remote control breaker, suitable for heavy duty intermittent operation; bi-metal stripping is used; high speed magnetic short circuit is employed which makes interrupting of currents up to 10,000 amperes possible.

TANK PRESSURE. Pressure Phenomena in Oil-Circuit Breakers, W. M. Leeds. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 152-156, 14 figs. Oscillograph records of pressure in medium and high-speed breakers show that tank walls are subjected to pressure surges of very steep wave-front having definite frequency between 10 and 60 cycles per sec.; from results of large number of laboratory tests, theory has been developed to account for these pressure waves.

Condensers

Synchronous Versus Asynchronous Condensers, A. Mandl. *AEG Progress*, vol. 7, no. 1-2, Jan.-Feb. 1931, pp. 47-53, 5 figs. It is investigated in which instances it is advisable to employ synchronous or asynchronous condenser; subject matter is based on condensers of medium and large capacity; range of output between 6000 and 60,000 kva. for regulating voltage of correspondingly large networks.

POWER FACTOR IMPROVEMENT. Starkstrom-Kondensatoren zur Blindstrom-Kompensation und ihre Wirtschaftlichkeit in Industrieanlagen (Electric Condensers for Reactive Power Compensation and their Economy in Industrial Installations), H. Cypra. *Elektrizitaet im Bergbau*, vol. 5, no. 11, Nov. 15, 1930, pp. 216-219, 6 figs. Advantages over rotating phase correcting machinery; no-load consumption of condensers practically is negligible, they do not need supervision and require no extra operating room; AEG equipment is illustrated.

SYNCHRONOUS. Developments in Hydrogen-Cooled Condensers, C. J. Fechheimer. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 165-169 and 178, 5 figs. Devices incorporated to safeguard equipment in practically every conceivable way are briefly described, repetitions of previous publications being avoided wherever possible; it is believed that tendency in future will be toward simplification, and reduction in number of auxiliary devices; test results are given. Bibliography.

Control

BRIDGES. Variable Voltage Control Improve Bridge Operation. *Elec. West*, vol. 66, no. 3, Mar. 1, 1931, pp. 141-143, 3 figs. West Spokane Street Bridge in Seattle; from engineering standpoint is unique not only in layout and design of its apparatus but also because it is first on Pacific coast and one of first in country to utilize advantages of variable voltages for controlling leaf movement; by use of separate motor-generator set, source of variable armature voltage is provided for regulating speed of driving motors.

REGENERATIVE. Le freinage électrique en courant continu des trains sur pentes (Electric Braking with Direct Current of Trains on Slopes), E. Gratzmuller. *Industrie Electrique*, vol. 40, no. 926, Jan. 25, 1931, pp. 33-42, 5 figs. Tentative study of principles in braking with recuperation of energy under normal speed and transitory high speeds.

Regenerative Control in Paris, Bacqueyrisse. *Tramway and Ry. World*, vol. 69, no. 8, Feb. 12, 1931, pp. 83-84. Reply to British viewpoint of regenerative control; application to British Systems; gear ratio; reports on damage.

Converters

FREQUENCY. Frequency-Changers, S. Neville. *Power Engr.*, vol. 26, no. 299, Feb. 1931, pp. 46-49. Characteristic types, limitations and operating features of synchronous, induction-synchronous and asynchronous frequency changers.

Dielectrics

Contribution to the Theory of Dielectrics, G. Gueben. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 11, no. 69, Feb. 1931, pp. 405-410. It is supposed that current in dielectric is due both to contribution of dipoles and to presence of ions; part due to each of these two elements is determined and formula is proposed for general expression of current in solid dielectric.

Modern Theories of Dielectrics, W. N. Stoops. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 183 and 185. Two of first questions asked about any new insulating material have to do with its dielectric constant and its power-factor; within recent years, understanding of these properties of dielectric has increased greatly; general discussion of modern conceptions is given.

Dynamometers

ELECTRIC. The Dynamo-Electric Machine as a Dynamometer, B. P. Haigh. *Engineering*, vol. 131, no. 3394, Jan. 30, 1931, pp. 129-131, 12 figs. Modifications required to enable standard dynamo or motor to measure torque in its shaft, and certain precautions that should be observed in order to obtain accurate results; examples installed in Engineering Laboratory of Royal Naval College, Greenwich, are illustrated.

Education

ENGINEERING. Some Facts about the Scholastic Achievements of Engineering Students, H. W. Miller and J. C. Palmer. *Jl. Eng. Education*, vol. 21, no. 5, Jan. 1931, pp. 371-383, 9 figs. Investigation of results accomplished by segregating high and low students in classes by themselves.

Electric Drive

CANALS. The Welland Ship Canal—XVII. *Engineering*, vol. 131, no. 3395, Feb. 6, 1931, pp. 166-169, 15 figs. partly on p. 176. Whole of machinery required for operation of canal is electrically driven; complete system of electric lighting is installed and master of controls, interlocking and signaling are all electrically operated; power is purchased from Hydro Electric Power Commission of Ontario, power being transmitted over canal transmission line and transformed in and distributed from substations; on canal power is used mainly for operation of locks and bridges, lighting and heating control houses and substations; details of electric equipment and insulation.

CEMENT PLANTS. Modernizing a Cement Works, S. Hopferwieser. *Brown Boveri Rev.*, vol. 18, no. 3, Mar. 1931, pp. 116-119, 11 figs. Various drives and equipment installed at S. A. des Ciments Portland de Lorraine, Strasbourg; by extensions and improvements made; daily production of plant was increased in this way from 160 tons to about 800 tons.

COAL HANDLING. The Use of Alternating Current for Handling Coal—I, R. F. Emerson. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 104-111, 12 figs. Conditions peculiar to handling of coal, coke and ashes, such as effect of these different kinds of dust on motor insulation and special precautions to be taken; handling of coal by coal towers, bridges and cranes, rotary-type car dumpers; equipment and performance characteristics.

STEEL PLANTS. An Electrified Steel Mill, R. H. Wright. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 146-149, 8 figs. Improvements completed last year in Alabama City plants of Gulf States Steel Co. make this one of most modern steel mills; 7000-hp. adjustable-speed d-c. reversing motor, capable of developing 19,000 hp. momentarily, drives 40-in. blooming mill; first installation of synchronous motors on roll mill; intermediate roll trains are driven by 2750-, 2100-, 1750- and 1300-hp. motors.

Electric Discharge

GLOW. On the Distribution of Space-potential in High Frequency Glow Discharg , D. Banerji and R. Ganguli. *Lond., Edinburgh, and Dublin Philosohpical Mag. and Jl. Science*, vol. 1, no. 69, Feb. 1931, pp. 410-422, 5 figs. Exploring collector method of Langmuir and Mott-Smith has been applied to study space-potential distribution, ionic concentration, current density, and average electronic velocity in case of high-frequency discharge through rarefied air and oxygen; it has been found that potential distribution is symmetrical about middle point of discharge-tube, both electrodes acting as cathodes in corresponding d. c. discharge.

Electric Equipment

DESIGN. Tendances actuelles dans l'équipment électrique des centrales (Present Trend in Design of Electric Powerplant Equipment), V. Olerin. *Union des Ingênieurs Sortis des Ecoles Speciales De Louvain—Bul. Technique*, no. 4, 1930, pp. 41-76, 23 figs. Development in high capacity electric powerplant and substation machinery and equipment in United States and Europe is reviewed and illustrated; wiring diagrams are given.

Electric Heating

The Heating of Buildings, D. J. Bolton. *Elec. Rev.*, vol. 108, no. 2777, Feb. 13, 1931, pp. 306-307. General considerations governing use of electricity for purpose; fuel costs of alternative systems; comparative efficiencies; capital expenditures; costs of operation; indirect advantages of electric heating; thermodynamic principles.

INDUSTRIAL. Industrial Electric Heating. *Elec. Engr. Australia and New Zealand*, vol. 7, no. 10, Jan. 15, 1931, pp. 365-369. Applications and advantages of electricity for industrial heating in which author points out that electricity competes successfully against other heating media on account of its advantages rather than its cost.

Electric Lines

GROUNDING. Earthing of E.H.T. Systems, J. Eccles. *Elec. Times*, vol. 79, no. 2050, Feb. 5, 1931, pp. 243-244, 3 figs. Practise of earthing e.h.t. transmission systems through tuned choke coils instead of through non-inductive resistances has been developed principally on continent and for certain systems it has indisputable advantages.

CALCULATION. Sinusoidal Currents in Linearly Tapered Loaded Transmission Lines, J. W. Arnold and P. F. Bechberger. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 2, Feb. 1931, pp. 305-310, 3 figs. Working formulas for calculation of input impedances and attenuation are obtained for transmission line in which resistance and inductance per unit length are linear functions of distance, and in which capacitance and leakance are constant; generalized functions depending on initial constants and rate of taper are introduced, in such way that formulas and functions are analogous to usual formulas and hyperbolic functions.

HIGH TENSION. Ueber ungleichmaessig verteilte Zusatzlast bei Hochspannungsleitungen mit Haengisolatoren (Unequally Distributed Additional Load in Electric High Tension Lines on Suspension Insulators), O. Strand. *Elektrotechnische Zeit.*, vol. 52, no. 10, Mar. 5, 1931, pp. 316-320, 6 figs. Method for calculation of all asymetric loading conditions for stranded conductors by which it is possible to determine irregularities in span, vertical load insulators, etc., in simple manner.

Electric Signs

NEON. A Short Analysis of the Neon Sign Situation, A. W. Murdock. *Elec. News*, vol. 40, no. 4, Feb. 15, 1931, pp. 49-50. As operating costs over 5-year period are only 25 per cent of incandescent signs large increase in their use may be expected.

Electrolysis

WATER PIPE. Why Prohibit Grounding of Telephone Cable Sheaths on Water Pipes, I. D. Van Giesen. *Water Works Eng.*, vol. 84, no. 3, Feb. 11, 1931, pp. 159-160 and 180 and 183, 6 figs. Report on experiments conducted by electrolysis engineer of Department of Water and Power, Los Angeles, Cal.; use and effects of a.c. and d.c. currents; dual nature of stress in charged conductor; joint use of poles causes trouble; noise reduced by grounding; investigation of noise arising from joint use of poles; effects of grounding; how ground is to be made. Before Am. Water Works Assn.

Furnaces

Les fours électriques a récupération aux usines citroen (Recuperative Electric Furnaces in the Citroen Plants). *Jl. du Four Electrique*, vol. 40, no. 1, Jan. 1931, pp. 11-13, 4 figs. Heat treatment equipment saving approximately 20 to 30 per cent of electric power over ordinary furnaces as usually employed in United States; two of this type of furnaces are installed in Citroen plant in Paris by Jean Aubé, in which parts of 500 cars produced in 24 hr. are handled; operation requires 4 men, against 10 men required by 12 old furnaces, which they replace.

HEAT TREATING. Electric Furnaces and Low-Temperature Treatments, J. E. Oram. *Metallurgia*, vol. 3, no. 15, Jan. 1931, pp. 94-96, 5 figs. Low-temperature heat-treatments offer additional scope to electric furnace; low operating and maintenance costs and ease of temperature control are associated with this type of equipment.

HIGH FREQUENCY. Hoegfrekvensugnen Ur Elektrisk Anlaeggningssynpunkt (High-Frequency Furnaces from Standpoint of Electric Engineers), J. Oesterberg. *Teknisk Tidskrift*, vol. 61, no. 1, Jan. 3, 1931, (Elektroteknik), pp. 8-12, 11 figs. General considerations in design of furnaces for melting of metal, and data on installations in Sweden built by AEG.

INDUCTION. Bisher unbekannte Badbewegungen bei Induktionsoefen (Heretofore Unknown Bath Movements in Induction Furnaces), E. F. Russ. *Giesserei*, vol. 18, no. 8, Feb. 20, 1931, pp. 165-166, 1 fig. Review of previous research on bath movements in induction furnaces, notably that of Hering and Northrup and formulation of pinch effect and Northrup effect; results of author's experiments, and conclusions based thereon.

LABORATORY. Beschreibung eines Zerreissofens (Tensile Testing Furnace), O. Holtschmidt. *Mitteilungen aus den Forschungsanstalten*, vol. 1, no. 2, Nov. 1930, pp. 40-44, 4 figs. Price 2.50 m. Requirements of laboratory furnace for testing influence of temperature on properties of steel, and description of electric furnace developed and perfected in course of eight years; elongation measurements.

Generators

ROTORS. Fatigue Tests of Model Turbo-Generator Rotors, R. E. Peterson. *Mech. Eng.*, vol. 53, no. 3, Mar. 1931, pp. 211-215, 10 figs. Results of tests of rotor end forgings to obtain data as to safety during operation; tests with fatigue loading only, and with superimposed centrifugal stressing.

STABILITY. Generator Stability Features Fifteen Mile Falls Development, R. Coe and H. R. Stewart. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 139-143, 9 figs. Generators in New England Power Association's 15 mile falls development are notable for several reasons; they are of new umbrella type which has but one guide and one thrust bearing, both located below rotor; to insure stability generators were built with especially low transient reactance, large flywheel effect special damper winding, and quick-response excitation system; electric and mechanical characteristics are discussed, notes on testing.

SYNCHRONIZATION. Measurement of the Load Angle of Synchronous Machinery, J. C. Prescott and E. W. Connon. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 410, Feb. 1931, pp. 281-289, 12 figs. Method of determining by direct measurement synchronizing power flowing to or from alternator for given angular displacement of rotor from normal running position; method was developed in connection with some experiments on natural free period of alternators, but results of measurements can be used to obtain effective reactance of machine and demagnetizing and cross magnetizing coefficients for armature field; experimental results are quoted.

WATERWHEEL. 20,000 Kva. Water Wheel Alternators. *Engineer*, vol. 151, no. 3971, Feb. 13, 1931, pp. 192-194, 9 figs. Large alternators forming initial generating plant of Waikaremoana hydroelectric power station of New Zealand constructed and installed by Metropolitan Vickers Electrical Co.; normal rating is 20,000 kva.; normally they are driven at 428 r.p.m. but are designed for overspeed of 85 per cent; current is generated at 11,000 volts and each generator feeds through its own bank of step-up transformers on to 110,000-volt busbars; lubrication is provided by low-pressure oil supply.

Water-Wheel Alternators; Trend of Development, F. Ruedenberg. *A EG Progress*, vol. 7, no. 1-2, Jan.-Feb. 1931, pp. 17-22, 11 figs. Meticulously prepared designs have given A.E.G. assurance that construction of much larger hydro-power alternators (over 100,000 kva.) can be tackled while retaining fundamental arrangements approved for so many years and applying constructional materials obtainable at present day.

High Head Impulse Unit With Unique Control. *Elec. News*, vol. 40, no. 5, Mar. 1, 1931, pp. 31-34, 3 figs. Vancouver Island Power Co.'s Jordan River plant now complete with fourth unit; unit is 15,000-kva., 6600-volt, 60-cycle three-phase English electric generator, driven at 300 r.p.m. by two tangential waterwheels, one mounted on each end of shaft and overhanging bearings; waterwheels are together rated at 18,000 b.hp.; more than 1¾ mi. of steel penstock required.

Humming

ELECTRIC LINES. Le Ronflement des lignes aériennes et les perturbations atmosphériques (Humming of Aerial Lines and Disturbances in Atmosphere), A. Noden. *Acadêmie des Sciences—Compie Rendus*, vol. 191, no. 20, Nov. 17, 1930, pp. 959-961; see also brief translated abstract in *Experimental Wireless*, vol. 8, no. 89, Feb. 1931, p. 91. Valuable meteorological information can be obtained from humming of aerial lines; two such lines, at right angles are installed at Biarritz observatory; humming, which as rule occurs in calm atmosphere, is attributed to electrostatic attractions provoked by successive small masses of highly charged air passing rapidly over line in direction at right angles to it.

Hydroelectric

EQUIPMENT. Some Outstanding Trends in Canadian Central Station Practise, D. Anderson. *Elec. News*, vol. 40, no. 4, Feb. 15, 1931, pp. 42-44, and 50, 5 figs. Tie-bank connections were constructed for interchange of power on Southern Canada and Shawinigan systems and on East Kootenay and Calgary Power systems; 8000 ft. river crossing was built to carry power from Falls River to Prince Rupert, B. C.; welded type generators have found broad application in new plants constructed; field of propeller runners was increased to 66 ft. head; notes on metal-clad switchgear, welded and umbrella-type generators, higher head propeller runners, long distance transmission spans.

PAPER MILLS. An Ideal Site Developed the High Falls Plant. *Elec. News*, vol. 40, no. 4, Feb. 15, 1931, pp. 39-42, 6 figs. James MacLaren Co. has filed plans with Dominion government for another development, of 120,000 ultimate hp. capacity with 200-ft. head at point farther down river between Buckingham and Masson; it is at latter town 25 miles below High Falls, that company has stepdown transformer station for its new large paper mill which went into operation last September; hydr electric plant and transmission lines are described.

Insulation

PAPER. Paper Applications in Electrical Industry, W. H. Anderson. *Paper Trade Jl.*, vol. 92, no. 7, Feb. 12, 1931, pp. 39-41. Paper before Tech. Assn. Pulp and Paper Industry, indexed in Engineering Index 1930, from Paper Mill, Dec. 27, 1930.

PHENOLIC. Electrical Materials Commonly Used—Laminated Phenolic Insulation, W. C. Hirsch. *Elec. Mfg.*, vol. 7, no. 2, Feb. 1931, pp. 57-59, 2 figs. Laminated phenol-resinoid sheets range in size up to about 39 by 47 in.; thicknesses range from 1/64 to 5 in.; tubes and rods come in lengths of 18, 24, 36, and 48 in., ranging in diameter from 1/8 to 12 in. with 1/32- to 1¼-in. wall thicknesses; rods range in diam. from 1/8 to 4 in.; there is almost no limit to variety of applications of this hard and tough material.

VARNISH. Insulating Varnishes, H. N. Bassett. *Elec. Times*, vol. 79, no. 2054, Mar. 5. 1931, pp. 433-434. Classification; solvents; impregnation and drying; examination and testing; other uses.

WOOD. Woods for Insulation, A. F. Dunton and A. W. Muir. *Elecn.*, vol. 106, no. 2750, Feb. 13, 1981, pp. 237-239, 6 figs. Varieties used; methods of impregnation; breakdown voltages of treated woods.

Lamps

GAS-FILLED. Gasfilled Lamps, A. E. Williams. *Elec. Rev.*, vol. 108, no. 2779, Feb. 27, 1931, pp. 371-372, 3 figs. Notes on chemical processes involved in their manufacture; arrangement of "gettering" apparatus; argon gas; gas pressure in lamp; chemical "getters."

GLOW. Low-Voltage Tube Lighting Available. *Elec. World*, vol. 97, no. 7, Feb. 14, 1931, p. 324, 1 fig. New era in commercial application of luminous tubes was forecasted in recent announcement by Claude Neon Lights, Inc. New York, of commercial production of units developed for general interior lighting on 110 volt and 220 volt service; rare gas tubes are now applicable to commercial, industrial and special residential lighting, and greatly increased range of color effects has been achieved.

Neon Tube Light and Factors Governing Its Life, R. R. Machlett. *Franklin Inst.—Jl.*, vol. 212, no. 3, Mar. 1931, pp. 319-326. Electrical characteristics; function of pressure; sputtering; life effect of electrode material and of pressure on life of tube.

Lighting

Calcul de l'éclairage par projecteurs (Calculation of Lighting by Pro-jectors), G. Beylon. *Electriciens*, vol. 47, no. 1509, Feb. 1, 1931, pp. 60-62, 1 fig. Calculation of projected light is simple in theory but difficult and in exact when location of lighting equipment is close to surface to be lighted, simple numerical analysis for various cases is given.

SERIES. Standard and Proposed Cutout Designs for Series Street-Lighting Circuits, H. E. Butler. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 112-114, 2 figs. Inspection of designs, together with considerations showing that much study has been given to problem of developing best type of film cut-out (at present special-oxide form) for use on either low or high voltage series street-lighting circuits; cut-outs of new designs, special-oxide disk type and electromagnetic type will function satisfactorily at low-voltage rating.

Lightning

ELECTRIC LINES. Der Blitzschlag in Hochspannungsanlagen und seine Folgen (Lightning Striking in High Tension Lines and Consequences Thereof), E. Flegler. *Elektrotechnische Zeit.*, vol. 52, no. 5, Jan. 29, 1931, pp. 129-133, 4 figs. Form of resulting waves; requirements of protective equipment against excessive voltages are pointed out.

Meters

WATTHOUR. Checking Load and Power Factor from Watthour Meter Readings, M. A. Faucett and J. O. Kraehenbuehl. *Factory and Indus. Mgmt.*, vol. 81, no. 3, Mar. 1931, pp. 427-428. Determination of corrected power and power factor shown by example using G. E. meter of D-7 type, 100 amperes, three-phase and 220 volts.

Motors

DESIGN. Sub-Synchronous and Standard-Speed Motors. *Product Eng.*, vol. 2, no. 2, Feb. 1931, pp. 67-70, 8 figs. Advantages of sub-synchronous motors which run at 200 r.p.m. or 600; practical discussion of proper methods in selection of motor for clocks, recording instruments and light power requirements. (Continuation of serial.)

DIRECT-CURRENT. Berechnung von Gleichstrommotoren nach preiswirtschaftlichen Gesichtspunkten (Calculation of D-C. Motors According to Economic Viewpoints as to Costs), R. Hofmann. *Elektrotechnik und Maschinenbau*, vol. 49, no. 5, Feb. 1, 1931, pp. 81-85, 1 fig. Determination of favorable pole and yoke inductions and of most advantageous magnetic flux; practical example is given.

FRACTIONAL HORSEPOWER. Closed Iron Ring Motor. *Elec. Times*, vol. 79, no. 2051, Feb. 12, 1931, pp. 282-284, 7 figs. Motor described presents some novel features in design and operates on entirely new principle; original invention was made by J. Zetsche, of Germany, in attempt to produce gramophone motor having superior characteristics to those of existing designs.

Modernize Wiring and Motors for Better Voltage Regulation, L. L. Elden. *Elec. World*, vol. 97, no. 9, Feb. 28, 1931, pp. 416-417. Failure to recognize merits of new developments in motor design and importance of more adequate wiring will result in many cases in poor service and economic losses which cannot be compensated for otherwise; figures on sources of poor regulation point to conditions which should no longer be overlooked by progressive power companies; test data on 387 motors causing lighting fluctuations; motor-starting currents and overloaded wiring causing complaints.

INDUCTION. Moteur asynchrone auto-compensé a démarrage automatique (Self Compensated Induction Motor for Automatic Starting), P. Letrilliart and P. Fourquet. *Revue Générale de l'Electricité*, vol. 29, no. 5, Jan. 31, 1931, pp. 163-178, 15 figs. Mathematical analysis of principles, characteristics and performance of motor with 2 windings on rotor and 2 on stator.

OSCILLATING ARMATURE. Ein neuer Wechselstrom-Kleinmotor (Novel Fractional Horse Power A. C. Motor), C. Kuehnel. *Elektrotechnische Zeit.*, vol. 52, no. 9, Feb. 26, 1931, pp. 267-268, 3 figs. Oscillating armature motor by which armature oscillates synchronously which each half cycle around axle and then are converted into rotating motion is described; practical applications are discussed.

STARTING. Methodes de démarrage des moteurs asynchrones diphasés a cage d'écureuil (Methods for Starting of Two-phase Induction Motors with Squirrel Cage Rotor), Marre. *Electriciens*, vol. 47, no. 1510, Feb. 15, 1931, pp. 74-76, 6 figs. Various hook ups, their features and analysis.

TESTING. Eine neue Methode zur kuenstlichen Belastung von Induktionsmotoren (New Method for Artificial Loading of Induction Motors), A. M. Bamdas. *Elektrotechnik und Maschinenbau*, vol. 49, no. 5, Feb. 1, 1931, pp. 86-88, 2 figs. Method developed by author and S. B. Eliaschewitz by which stator and rotor are connected to separate networks.

Networks

DESIGN. Rural Electrification, A. Ekstrom and V. Ekstrom. *Elecn.*, vol. 106, no. 2753, Mar. 6, 1931, pp. 357-359, 2 figs. Simple method of calculating most economical cross section of conductor for given maximum permissible drop in voltage.

STABILITY. Power-system Stability—II, R. D. Booth and O. G. C. Dahl. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 131-141, 10 figs. Notes on generator design and reactance; line and transformer reactances; synchronous condenser size and reactance; load characteristics; voltage regulator and exciter characteristics; governor action; inertia of rotating machines; damper windings and their effects; effect of different grounding systems; effect of circuit-breaker operation; determination of transient operating characteristics.

Photoelectric

AMPLIFIERS. Ueber die Verstaerkung von Photozellenstroemen (Amplification of Current from Photoelectric Cells), H. Simon. *Elektrotechnische Zeit.*, vol. 52, no. 9, Feb. 26, 1931, pp. 264-266, 10 figs. Various types are described and possibilities of application are discussed.

COLOR MEASUREMENT. Photo-Electric Cell Has Definite Place in Color Measurement, W. M. Scott. *Textile World*, vol. 79, no. 8, Feb. 21, 1931, pp. 886-889, 4 figs. Uses, limitations and future possibilities of photoelectric cell; determination of light energy; recent developments.

Power

DOMESTIC. Poughkeepsie Plan Quintuples Domestic Usage, Triples Revenue, A. M. Perry. *Elec. World*, vol. 97, no. 10, Mar. 7, 1931, pp. 444-449, 4 figs. Domestic use of electricity has been nearly multiplied by five and revenue increased three times what it was just before "full-use" electric home plan was inaugurated by Central Hudson Gas & Electric Corp.; customers have changed from limited use of electric conveniences to "full-use" and obtained nearly five times as much energy as formerly for only half unit price, including amortization of equipment cost; analysis based on one year's experience of plan is given.

INDUSTRIAL PLANTS. Bringing Electric Power into the Small Plant, R. H. Rogers. *South Power Jl.*, vol. 49, no. 2, Feb. 1931, pp. 99-103, 7 figs. Accumulated experience of years in industrial electrification has determined certain practises and methods as being most successful from standpoints of procedures of power, insurance underwriters, and consumer; meter and lighting; practical application of electric drive; electric motor control.

Power Factor

Power Factor Determination, C. F. Dalziel. *Elec. West.*, vol. 66, no. 3, Mar. 1, 1931, pp. 124-126, 5 figs. Practical methods of measuring power factor and verifying reverse power relay connections in three-phase power systems. (To be continued.)

Power Plants

Steam and Diesel Units Combine to Give Low Over-all Power Costs, E. J. Kates. *South. Power Jl.*, vol. 49, no. 2, Feb. 1931, pp. 52-54, 2 figs. In power plants serving dual needs of power and steam, Diesel engine indicated as companion unit to steam prime mover, when power demand exceeds steam or heat demand; tabular results of comparative power cost studies for large department store.

Radio

AMPLIFIERS. Maximum Undistorted Power Output, G. Smiley. *Radio Eng.*, vol. 11, no. 2, Feb. 1931, pp. 36-39 and 50, 7 figs. Engineering analysis of factors determining amplifier design and performance.

CONDENSER LOSSES. The Losses in Variable Air Condensers, W. H. F. Griffiths. *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 124-126, 5 figs. Method of analysis is amplified by omitting all reference to voltage or current, reasoning being based merely upon impedance triangle of capacity and resistance in series which gives well known simple expression for power factor, to high degree of approximation.

CONDENSER TESTING. By-Pass Condenser Production Test Equipment, F. W. Stellwagon. *Electronics*, vol. 2, no. 2, Feb. 1931, pp. 504-505, 5 figs. Grebe Co. uses by-pass condenser test apparatus capable of completely testing over 500 by-pass condenser units per hour; tests include ten-second test at 200 per cent of rated d-c. voltage, discharging of charged condensers, testing insulation between condenser terminals and container, and checking capacity of four condenser sections.

DISTORTION. An Analysis of Distortion in Resistance Amplification, E. B. Moullin. *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 118-123, 4 figs. Method of predicting from static characteristic output of resistance coupled amplifier; certain form of equation is assumed for characteristic and this leads to simple rules for deducting fractional amplitudes of second and third harmonic currents.

RECEIVER TESTING. Special Instruments for Radio Receiver Production Testing, R. P. Glove. *Electronics*, vol. 2, no. 2, Feb. 1931, pp. 500-501, 4 figs. Notes on adaptation of Wheatstone bridge; condenser test equipment; visual test apparatus; production testing of audio amplifiers; loud speaker testing.

TUNING. Selectivity and Response, E. E. Wright. *Experimental Wireless*, vol. 8, n . 90, Mar. 1931, pp. 133-134, 1 fig. Attempt to find from theoretical reasoning response of selectivity tuned circuit to steadily modulated wave.

Railroad

ELECTRIFICATION. West Side Freight Electrification of New York Central Railroad, W. J. Hedley and J. F. Walker. *Gen. Elec. Rev.*, vol. 34, no. 3, Mar. 1931, pp. 165-169. 7 figs. West side improvement involves, in addition to electrification work being carried out by Railroad Company, variety of other changes which are being done jointly with City of New York, including elimination of tracks from streets and provision of space for high speed traffic roadway from Canal Street and West Street to 79th Street and Riverside Drive; notes on road freight locomotives; switching locomotives; operating conditions.

The Reading-Philadelphia Suburban Electrification, G. I. Wright and A. I. Totten. *Gen. Elec. Rev.*, vol. 34, no. 3, Mar. 1931, pp. 173-179, 13 figs. Enlargement of service to include through passenger and freight traffic; single-phase, 25-cycle, 12/36-kv., three-wire system, as finally decided upon, consists essentially of frequency-changer station at Wayne Junction to be owned by Philadelphia Electric Company; initial peak load, in suburban zone, will approximate 9000 kw. or about 13,000 kva.; frequency-changer station; distribution system; multiple-unit cars; traction motors; control and auxiliary equipment, are discussed.

SIGNALING. Automatic Block Signaling on the Canadian Pacific Railway, A. K. Kidd. *Elec. News*, vol. 40, no. 5, Mar. 1, 1931, pp. 39, 40 and 42, 3 figs. Semaphores are being replaced with colored light signals which may have effective range from 3000 to 4000 ft. in bright sunlight; most recent development in signaling is centralized traffic control.

D. and H. Handles Four Ends of Double Track by Centralized Control. *Ry. Age*, vol. 90, no. 8, Feb. 21, 1931, pp. 411-412, 3 figs. Installation between Center Village, New York, and Lanesboro, Pa. has solved operating problem on two short sections of single track and permits closing of four offices; operating characteristics; outside construction; track and signal plan of centralized traffic control territory.

Substations

High Power Mercury Arc Rectifiers, N. von Kotschubey. *Elec. Times*, vol. 79, no. 2053, Feb. 26, 1931, pp. 377-380, 6 figs. Description of substation plant of new South Wales government railways and tramway system Sydney; adoption of mercury arc rectifiers not only simplified service conditions of N.S.W. Government railway substations, and reduced operation costs by increasing over-all efficiency of plants, but also considerably lowered initial cost of substations; tables showing how costs of three 1500-kw. 1500-v. rotary converter units at Belmore compare with those of identical rectifier substation at Epping.

Rate Making

POWER INDUSTRY. Electric Power Supply in the Limelight, L. R. Nash. *Stone and Webster Jl.*, vol. 49, no. 2, Feb. 1931, pp. 84-92. Public utilities supply more than two-thirds of electricity used; electric service highly developed in South; domestic and rural service; casual service rates below cost, service charge; rural rates; further rate practises; electric rates lower than general price level.

The Domestic Tariff, C. F. Mounsdon. *Elec. Rev.*, vol. 108, no. 2776, Feb. 6, 1931, pp. 232-233. It is claimed that practical difficulties experienced in use of any single-basis two-part tariff would be obviated by introduction of composite basis for fixed charge.

Relays

PROTECTIVE. Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 172-178, 16 figs. Overcurrent relays for generator differential protection; ratio-differential relays for generator protection; overspeed protection of generators; generator field protection; undervoltage time-delay protection for motors; synchronous condenser protection; synchronous-converter protection; motor-generator protection; protection of frequency-changer sets.

Safety Devices

ELECTRIC APPLIANCES. The Safety of Domestic Electrical Appliances, G. W. Stubbings. *Elec. Engr. Australia and New Zealand*, vol. 7, no. 10, Jan. 15, 1931, pp. 373-374. Various methods that are employed with view to increasing safety, viz., earthing, construction of insulating material, low working voltage, and use of leakage relays; author points out that each has certain shortcomings, and therefore further research into safety methods is necessary.

Ship

ELECTRIC EQUIPMENT. The Electrical Equipment of Ships, J. E. Allen, vol. 131, no. 3395, Feb. 6, 1931, p. 191. Difference in practise between electricity at sea and on land; totally enclosed motors, specially designed to prevent entry and deteriorating effects of moisture, oily vapor, salt-laden air and seawater; use of contactors for making and breaking first step of starting resistance; deck machinery; rubber-insulated cables. Before Inst. Mar. Engrs.

Starters

MOTOR. Small A-C. Motor Starters, J. P. S. Pillans. *Elec. Rev.*, vol. 108, no. 2779, Feb. 27, 1931, p. 369. With view to providing all desirable operation and protection features at moderate cost author suggests modification of simple switch-fuse.

Substations

HEATING. Electric Heat for Substation and Office Buildings, P. Sporn. *Elec. World*, vol. 97, no. 10, Mar. 7, 1931, pp. 463-464, 3 figs. Number of substations and office buildings on properties of various subsidiaries of American Gas & Electric Co. have been equipped with electric storage type heating systems; in Hall system employed in all these installations water is heated by direct contact with totally inclosed immersion units; general basis on which to make calculations for justifying or disproving economic feasibility of electric heating, is outlined.

Switches

VACUUM TUBE. A Vacuum-tube Time Switch. W. K. Kearsley. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 128-129, 2 figs. Type of equipment described is outcome of developmental work to produce time switch that has no moving parts; in it, vacuum tubes and other static electrical equipment accomplish what is ordinarily considered to be functions of mechanisms and motion.

Switchgear

LOSSES. Eddy Current Losses in Heavy Current Switchgear—I, J. E. Shaw. *World Power*, vol. 15, no. 86, Feb. 1931, pp. 109-113, 7 figs. Measurement of iron loss in large oil switch tanks and switch tops with 5000 amps. flowing in loop conductor; methods adopted for obtaining conditions similar to those in practise; from results obtained on various sizes of switch tanks and switch tops empirical formulas are derived whereby losses may be estimated in any desired case to within 10 per cent and thence temperature rises estimated. (To be continued.)

Telephone

CARRIER CURRENT. Practising Economy in Carrier Operation, F. D. Dommerque. *Telephone Engr.*, vol. 35, no. 2, Feb. 1931, pp. 33-34, 1 fig. Loading coils are not practical on long distance lines when repeaters are introduced, but economical for straight toll lines and cables. (Continuation of serial.)

Transformers

DESIGN. Design Features of World's Largest Transformers, H. L. Cole and F. J. Vogel. *Elec. World*, vol. 97, no. 8, Feb. 21, 1931, pp. 374-377, 5 figs. World's largest power transformers; are located at Roseland, N. J., switching station of Public Service Electric & Gas Company; they form two 90,000-kva. transformer banks, with one spare unit stepping from 220,000 Y volts to 132,000 Y volts (or vice versa), with 60,000-kva., 11,000-volt delta-connected tertiary winding for supplying synchronous condensers; they are oil insulated, self cooled by radiators, single-phase units; 132,000-volt winding is made up of two separate windings, each of one-half capacity, for connection to double bus transmission system.

Transformer Developments. *World Power*, vol. 15, no. 86, Feb. 1931, pp. 130 and 133-134, 4 figs. Design and operating characteristics of "grid" transformer under construction for Central Electricity Board; record of export work carried out by British Electric Transformer Co., Ltd., in recent years.

INSTRUMENT. Ueber die Anforderungen an Stromwandler in Kraftwerken (Requirements of Current Transformers in Power Plants), G. Keinath. *Elektrizitaetswirtschaft*, vol. 30, no. 3, Feb. 1931, pp. 60-68, 9 figs. Summary of developments regarding properties, degree of exactness; secondary output; rating, class and current overloading capacity, test voltage and operating voltage, construction, system of insulation, thermal strength; excessive current rating, dynamic strength, surge proofness.

Calculation of Instrument Transformer Burdens, T. A. Hammond. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, pp. 115-126, 19 figs. Significance of burdens; effect of burden magnitude on accuracy; errors from secondary leads; single-phase burdens; effect of secondary interconnections.

Transients

An Experimental Method of Studying Transient Phenomena, H. M. Turner. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 2, Feb. 1931, pp. 268-281, 14 figs. Description of experimental method of studying transient phenomena which, by repeating phenomena synchronously enables one to observe it on screen of oscillograph as long as desired; method is based upon use of transient visualizer.

REFLECTION. Zur Metallreflexion (Metallic Reflection), J. Zahradnicek. *Zeit. fuer Physik*, vol. 65, no. 11-12, Nov. 14, 1930, pp. 814-823; see also brief translated abstract in *Experimental Wireless*, vol. 8, no. 89, Feb. 1931, p. 88. Theory of phenomena of reflection of plane; linearly polarized electromagnetic wave at metallic surface is developed from Maxwell's equations and appropriate boundary conditions; formulas for refractive index and index of absorption are given which are more general than those deduced by Drude for normally incident wave; suggestions for experiment at different angles of incidence are made and tables given.

TESTING. High-Voltage Surge Testing, F. D. Fielder. *Elec. Jl.*, vol. 28, no. 3, Mar. 1931, pp. 161-164, 7 figs. Oscillograph would have limited value without auxiliary circuits and devices which make it integral part of testing circuit; timing system must be available to sweep beam across film at proper instant and at known speed of one to sixty mi. per sec.; test surges must be reduced without distortion to few hundred volts for measurement; oscillograph must be synchronized with surge generator to within fraction of microsecond.

Trolleys

TRACKLESS. The Modern Trolley Bus as a Central Station Load Builder, C. A. Burleson. *Gen. Elec. Rev.*, vol. 34, no. 2, Feb. 1931, p. 130, 1 fig. Advantages of trolley bus as compared with street car are lower investment; elimination of track and paving charges; curb loading and unloading; flexibility in traffic; quiter operation; faster schedules; as compared with gas bus: lower operating cost; unlimited power supply; higher schedule speeds; better lighting and heating; quieter operation; absences of fumes; less fire hazard; cost of power is low and stable.

Maintenance and Operating Factors of Trolley Buses, G. W. Wilson. *Elec. Traction*, vol. 27, no. 2, Feb. 1931, pp. 79-81, 2 figs. Operating and maintenance costs compared and methods employed to eliminate various difficulties in service; solving braking difficulties; acceleration and distance curves showing relative performance of trolley buses and gas buses. Before Assn. Equipment Men, Southern Properties.

Vacuum Tubes

CATHODE RAY. Further Advances in the Technique of the Braun Tube, M. von Ardenne. *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 127-129, 4 figs. Cathode-ray tube for photographic recording, with new small type for visual observation is described; complete circuit of new cathode-ray equipment is given.

DETECTOR. High Level Plate Circuit Rectification, J. R. Nelson. *Electronics*, vol. 2, no. 3, Mar. 1931, pp. 550-551, 3 figs. Experimental procedure for attacking problem of plate rectification with large input voltages is receiving considerable attention at present; necessary experimentally determined curves may be obtained very easily so that anyone with measurable a-c. voltages and fairly accurate d-c. milliammeter may plot his own rectification characteristics for resistance load; characteristics curves of 227 tubes are given.

RECTIFIER. Zur Theorie eines Gleichrichters mit fallender, hyperbelformiger Kennlinie (Theory of Rectifier with Decreasing Hyperbolic Characteristics), O. Stierstadt. *Elektrische Nachrichten-Technik*, vol. 8, no. 1, Jan. 1931, pp. 31-38, 7 figs. Performance of rectifier tube is mathematically analyzed.

Welding

ARC. Arc Welding in 1931, J. F. Lincoln. *Boiler Maker*, Feb. 1931, pp. 50-51, 1 fig. Review of developments in arc welding during past year; equipment and processes; arc welding in structural engineering.

Arc Welds Cut Repair and Maintenance Bills, B. S. Havens. *Mill and Factory Illustrated*, vol. 8, no. 3, Mar. 1931, pp. 40-43, 14 figs. Examples of different applications. (To be continued).

ELECTRODES. Die Untersuchung von Elektroden fuer die Lichtbogenschweissung (Studies of Electrodes for Arc Welding), S. Sandelowsky. *Elektroschweissung*, vol. 2, no. 3, Mar. 1931, pp. 48-52, 15 figs. Strength of weld; texture of weld; shrinkage and stresses; economy. (Concluded.)

BRIDGES. Bemerkenswerte Schweissarbeiten an einer Eisenbahnbruecke (Welding of Railroad Bridge), E. Fromme. *Elektroschweissung*, vol. 2, no. 2, Feb. 1931, pp. 35-36, 4 figs. Modernization and making suitable for modern train traffic of 2500-m. long Moerdyk Bridge, in Holland, by electrically welded movable supports.

CAST IRON. The Use of Pure Iron Electrodes for Welding Cast Iron, H. D. Lloyd and J. S. G. Primrose. *Welding Jl.*, vol. 28, no. 328, Jan. 1931, pp. 18-22, 8 figs. Advantages of pure iron electrodes in making bed plate and repair electric motor casings; microphotographs illustrate burnt on weld in cast iron; phosphoric cast iron welded with soft pure iron.

MONEL METAL. Some Practical Notes on Welding Monel Metal. *Machy. (Lond.)*, vol. 37, no. 960, Mar. 5, 1931, pp. 733-734, 3 figs. Properties and use of monel metal with data on welding procedure; advantages of metallic arc welding of castings.

PIPE LINES. Pipe Line Welding, W. T. Graham. *Welding Engr.*, vol. 16, no. 2, Feb. 1931, pp. 42-44, 4 figs. Methods of preparing and welding of pipe developed by A. O. Smith Corporation; eight generator gangs consisting of foreman, mechanic and nine welders (one spare man) will produce average of 220, 10-in. weld, or 175, 16-in. welds or 132, 20-in. welds, or 110, 24-in. welds per 9-hr. day.

PRESSURE VESSELS. Welding Plates and Pressure Vessels, P. R. Hawthrone. *Welding*, vol. 2, no. 2, Feb. 1931, pp. 89-92, 5 figs. Tests show that by use of proper welding process, procedure control and method of annealing, welded vessels are made stronger than riveted ones.

Wiring

BUILDINGS. Vertical Distribution in World's Tallest Structure, J. A. Walsh. *Elec. World*, vol. 97, no. 7, Feb. 14, 1931, pp. 328-334, 10 figs. Empire State Building has frontage of 200 ft. on Fifth Avenue and 420 ft. on both 33d and 34th streets; gross floor area in 85 stories is 2,800,000 sq. ft. and rental area is slightly under 2,000,000 sq. ft.; 85th floor is 85 by 135 ft.; estimated connected load is 6000 kw. for lighting and 9600 hp. for power services; this estimate for connected lighting load was based on assumption of 6 amp. per ultimate lighting circuit; details of installation are given.

Industrial Notes

Anaconda Acquires Cable Accessories.—The Cable Accessories Corporation, formerly of Pittsburgh, and purchased by the Anaconda Wire & Cable Company, has been moved to the Hastings-on-Hudson, N. Y., plant, and is now operating to provide a complete cable service, including potheads, junction boxes, insulating compounds, jointing and miscellaneous materials.

Lincoln Electric Promotes George G. Landis.—According to a recent announcement, the Lincoln Electric Company, Cleveland, manufacturers of "Linc-Weld" motors and "Stable-Arc" welders, has advanced George G. Landis to the position of chief engineer. He has been with the company eight years. Many of the patents held by his employers, both on arc-welding equipment and electric motors, are the result of his work.

The Ohio Brass Company, Mansfield, Ohio, announces receipt of a contract from the Pennsylvania Water and Power Company covering all suspension insulators and hardware for its new 220-kv. transmission line connecting the Safe Harbor power development and Baltimore. This line, one of the most important in the system operated by Pennsylvania Water and Power Company, will serve Baltimore's industries.

Foster Wheeler Enters Boiler Industry.—With the acquisition of the plant and business of the D. Connelly Boiler Company, of Cleveland, the Foster Wheeler Corporation announces that it is prepared to furnish all types of boilers in the entire range of sizes and pressures. The Connelly Company was established more than fifty years ago. The Foster Wheeler Corporation has been supplying complete steam generators for some time, and has produced the various parts in its own works, with the exception of the boiler proper.

Inca Moves Eastern Office.—The Inca Manufacturing Division of the National Electric Products Corporation, has moved its eastern office from Newark, N. J., to 233 Broadway, New York. The new office, which includes both sales and service organizations, is under the direct supervision of Paul Stouffer. The main plant and general office are located in Fort Wayne, Ind., where a complete line of magnet wire and coils for the radio and electrical industries is manufactured. The eastern warehouse and coil winding department will continue to be maintained.

New Small Motors.—The Century Electric Company, St. Louis, announces a new line of fractional horsepower motors having mounting dimensions interchangeable,—in repulsion-start induction single-phase, split-phase single-phase, squirrel cage induction three-phase, and direct-current types. The bearing brackets of this design offer unusual protection against falling objects, dirt, or dripping water. The motors have rolled steel frames, welded steel feet, slotted for belt adjustment, and bearings machined from phosphor bronze castings.

New Underground Cable.—A new underground cable, known as "Flexlay," has been designed and is being manufactured by the National Electric Products Corporation, Pittsburgh. It is a flexible, highly insulated underground wiring system and is produced in three different types: non-metallic, semi-metallic and full-metallic which is better known as Parkway Cable. Flexlay may be laid in open trench without damage from abrasive handling, eliminating the use of clay or fibre ducts. It is so constructed as to adequately resist the action of soil textures, soil acids and prevailing moisture contents.

Large Turbine Order to Westinghouse.—The Public Service Electric and Gas Company at Newark, New Jersey, has recently awarded the Westinghouse Electric & Manufacturing Company an order for a 75,000 kw., 60 cycle, single-cylinder steam turbine-generator unit to be installed as the No. 6 steam unit at the Kearny generating station and which will bring the capacity in this station up to approximately 290,000 kw. The new unit will receive part of its steam from the mercury vapor condensers serving the 20,000 kw. G. E. mercury-vapor unit recently ordered from the General Electric Company.

In addition to the above the Public Service Electric and Gas Company has also ordered an 18,000 kw., high pressure, 60-cycle Westinghouse turbine unit for the Burlington generating station, to operate in connection with new boiler equipment on 650 pounds. With the addition of this new high-pressure turbine, the Burlington station is being remade into a most economical generating station and will be capable of developing approximately 55,000 kw. The approximate value of the two steam turbine units ordered from the Westinghouse Electric and Manufacturing Company is $1,250,000.

C. S. Knight, Jr., manager of the electrical and wire rope sales department of the American Steel & Wire Company, Chicago, died recently at the Worcester (Mass.) office of the company. Mr. Knight was 66 years old and a native of Worcester.

Trade Literature

Pole Top Switches.—Bulletin 36, 4 pp. Describes Pacific Electric type PS-1 pole top switches for light branch line construction where very moderate loads are to be controlled. Pacific Electric Manufacturing Corp., 5815 Third Street, San Francisco.

Lightning Arresters.—Booklets 2 and 3, 12 and 8 pp., respectively. Describe the construction and operation of crystal valve lightning arresters. Electric Service Supplies Company, 17th & Cambria Streets, Philadelphia.

Load Testing Set.—Bulletin, 2 pp. Describes a load testing set for measuring current without interruption to service. The complete equipment consists of a newly designed, highly efficient split-core current transformer, and a Weston ammeter, complete with connecting cable and plugging device. The entire equipment, with carrying case, weighs ten pounds. Electrical Engineering Sales Company, Los Angeles and San Francisco.

Illumination.—Bulletin A-1204, 24 pp., "Banishing the Twilight Zone from Modern Buildings." A discussion of present-day principles and practise in the interior lighting of modern buildings. Bulletin A-1206, 32 pp., "Bringing Cities Out of the Twilight Zone." A discussion of modern street lighting, presenting reasons and methods for providing well illuminated cities. Bulletin A-1208, 24 pp., "Skylines Beyond Twilight Zone." Discusses modern principles and practise in floodlighting. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Carbon Brush Manual.—Catalog B-131, 24 pp. This book differs from the ordinary carbon brush catalog, being designed to simplify the selection and specification of carbon and metal-graphite brushes. The new shunt nomenclature of the National Electrical Manufacturers Association has been adopted. The essential details for a complete brush specification are listed and discussed in the sequence which has been found most convenient. Tables of physical characteristics have been omitted. Instead, a cross index of grades and their applications simplifies the selection of a suitable grade for any service. Examples illustrate the manner in which the composite specification for a brush is derived and the price computed. National Carbon Company, Inc., Cleveland.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 6

The JOURNAL of the A.I.E.E. for June 1931

William S. Lee, *President*
F. L. Hutchinson, *National Secretary*

Publication Committee

W. S. Gorsuch, *Chairman*
H. P. Charlesworth E. B. Meyer
F. L. Hutchinson A. E. Knowlton

Publication Staff

George R. Metcalfe, *Editor*
G. Ross Henninger, *Assoc. Editor*
C. A. Graef, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY — changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in Electrical Engineering are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

REPUBLICATION from Electrical Engineering of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America. Number of copies this issue—

24,500

This Month—

Front Cover

Mt. Pisgah and The Rat, famous mountain group in the vicinity of the A. I. E. E. summer convention headquarters at Asheville, N. C.

"Nowhere are the skies bluer,
Nowhere do hearts beat truer,
And nowhere is friendship surer,
Than down in Carolina."

The Primary Network for Medium-Load Areas 400
By R. M. STANLEY & C. T. SINCLAIR

Vacuum Tubes and Their Applications 404
By W. C. WHITE

What Are Effects of Electric Shock? 406
By W. B. KOUWENHOVEN & O. R. LANGWORTHY

Electric Power in the Steel Industry 410
By G. E. STOLTZ

A Neutralized Welding Generator 412
By F. CREEDY

Some Effects of Unbalanced Faults 415
By R. D. EVANS & S. H. WRIGHT

Fundamental Basis for Distance Relaying 420
By W. A. LEWIS & L. S. TIPPET

Power Supply for Telephone Service 423
By R. L. YOUNG & R. L. LUNSFORD

— Turn to Next Page —

Helical Grooves in Slip-Rings and Commutators 427
By G. M. LITTLE

Synchronizing Salient-Pole Motors 430
By H. E. EDGERTON & PAUL FOURMARIER

A Concentrator for Printing-Telegraph Circuits 431
By WILLIAM B. BLANTON

Brazed Joints for Electric Conductors 434
By SAMUEL MARTIN, JR.

A Vacuum-Tube Voltage Regulator 436
By L. C. VERMAN & L. A. RICHARDS

Motive Power for Suburban Electric Lines 438
By CHARLES KERR, Jr.

Short Items —

Shallenberger Memoranda Recently Discovered . . 422

The Calculation of Generator Heat Losses 429

News of Institute and Related Activities 440
- **Local Institute Meetings** 454
- **Employment Notes** 459
- **Membership** 461
- **Engineering Literature** 462
- **Industrial Notes** 468
- **Officers and Committees** (For Complete list see pp. 81-84, January 1931 issue of ELECTRICAL ENGINEERING.)

R. M. STANLEY (F '23) in collaboration with C. T. Sinclair (M '29) describes the application of the network idea to medium- and low-load areas in the vicinity of Pittsburgh. *(See page 400.)*

ELECTRIC SHOCKS which do not involve the brain, respiratory nerves, or spinal cord seldom jeopardize life in animal organisms according to experimental findings discussed by W. B. Kouwenhoven (M '22) and O. R. Langworthy of Johns Hopkins University, Baltimore. *(See page 406.)*

EDWARD DEAN ADAMS, Associate of the Institute, Edison Pioneer, and energetic leader in engineering, financial, and philanthropic undertakings answers the Last Call, largely as a result of a recent automobile accident. *(See page 452.)*

SOUTHERN HOSPITALITY and the beauties of the Carolina mountains, often extolled by President Lee, should combine to attract many to the Institute's summer convention at the Grove Park Inn, Asheville, N. C. Incidentally there is offered a splendid technical program and, of course, the annual Mershon Trophy golf tournament. *(See page 440.)*

BETWEEN SYMPOSIA on noise and on lightning, the Rochester, N. Y., meeting of the North Eastern District enjoyed rather an animated program. In this issue there may be found a complete news story of the meeting and also a summary of some of the more pertinent discussions. *(See pages 441 and 445.)*

CONCERTED cooperative attack upon the central problems presented in present noise studies and investigations is being sought as an inter-society activity. Delegates attending a special joint meeting at Rochester, N. Y., attempted to reach common ground and succeeded in agreeing upon a statement of three fundamental questions. *(See page 443.)*

EDISON BUST was presented May 7 to the German Museum at Munich with fitting ceremony. *(See page 446.)*

PACIFIC COAST convention committee has arranged for extension of special rates at Tahoe Tavern, Lake Tahoe, California, as an aid to those who will spend their vacation there in connection with the convention. *(See page 449.)*

DR. CHARLES F. SCOTT, past-president of the Institute and long-time head of the electrical engineering department of Yale University, New Haven, Conn., is planning to retire. R. E. Doherty, formerly G. E. consulting engineer, has been appointed as his associate; will succeed him upon his retirement. *(See page 450.)*

STUDENTS participated actively in the Rochester, N. Y., district meeting; presented several interesting papers. *(See page 444.)*

FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Asheville, N. C.	June 22-26, 1931	Summer Convention	(Closed)
Lake Tahoe, Calif.	Aug. 25-28, 1931	Pacific Coast Convention	(Closed)
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	Oct. 26, 1931
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May - 1932	District Meeting	Feb. - 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

NATIONAL ELECTRIC LIGHT ASSOCIATION, annual convention, Atlantic City, (A. J. Marshall, 420 Lexington Ave., New York) June 8-12, 1931.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting, White Sulphur Springs, W. Va., June 14-19, 1931.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS, Cleveland, Ohio, (J. F. Kelly, Empire Bldg., Pittsburgh, Pa.) Jun 15-19, 1931

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, summer convention, Pasadena, Calif., (Chas. F. Roos, Secy., Smithsonian Institute, Washington, D. C.) June 15-20, 1931.

NORTHWEST ELECTRIC LIGHT AND POWER ASSOCIATION, (annual convention, cancelled by action of Executive Committee, Portland, Ore., April 10, 1931).

INTERNATIONAL CONFERENCE ON LARGE HIGH-TENSION ELECTRIC SYSTEMS, Paris, France, (Dr. C. O. Mailloux, 111 Fifth Avenue, New York, N. Y.) June 18-27, 1931.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, The Stevens Hotel, Chicago, (C. L. Warwick, Secy., 1315 Spruce St., Philadelphia, Pa.) June 22-26, 1931.

PACIFIC COAST ELECTRICAL ASSOCIATION, annual convention, Del Monte, Calif., (K. I. Dazey, 447 Sutter Street, San Francisco, Calif.) June 24-27, 1931.

ROCKY MOUNTAIN DIVISION N. E. L. A., annual convention, Stanley Hotel, Estes Park, Colo., Sept. 2-4, 1931.

ILLUMINATING ENGINEERING SOCIETY, annual convention, Pittsburgh, Pa., October 13-16, 1931.

The Primary Network for Medium-Load Areas

As a result of the noteworthy economic and operating success of the secondary a-c. network the same principle now is proposed for relatively high-voltage primary systems. Based upon economic studies of two Pittsburgh residential areas one primary network now is under construction there and a second all planned. Major details involved are given here and ten distinct advantages are enumerated.

By
R. M. STANLEY — Byllesby Engineering & Management Corporation
Fellow A. I. E. E

C. T. SINCLAIR — Byllesby Engineering & Management Corporation
Member A. I. E. E.

A NETWORK may be said to exist wherever the secondaries of two or more transformer banks not at the same location are connected in parallel to supply a common load. This definition is applicable to either high- or low-voltage systems. In this discussion a new design of primary network is considered which combines the principle of interconnecting 4-kv. mains and certain principles common to the design of secondary network, and which is fed directly at load-transmission voltage.

Generally speaking, the comparable characteristics of the older radial primary distribution system and the new primary network are as revealed in Fig. 1 and in Table I.

TABLE I—ELEMENTS OF A PRIMARY SYSTEM

Radial	Network
1. Transmission feeders from source of supply to substation	1. Transmission feeders from source of supply to substation
2. The substation	2. The transformers and switches
3. The distribution feeders	3. The primary mains
4. The mains	

From these it may be seen that the elements of the two systems are the same except for the elimination of primary feeders in the network design—an important item, but only one of several which permit a saving in initial cost as compared with the radial system.

In the typical radial system (Fig. 1) the substation is located of course as nearly as possible at the center of the expected load and each feeder terminates at its approximate load center. In the typical primary network of Fig. 1 the transformer capacity required for the entire area is distributed, each transformer at an intersection of primary mains and each intersection group constituting a unit, including regulators on transformer secondaries where and if required. Similar to the principle of secondary networks, it is desirable that the transmission supply to a given area comprise three or more feeders in order to reduce the spare capacity required to accommodate the possible loss of a feeder.

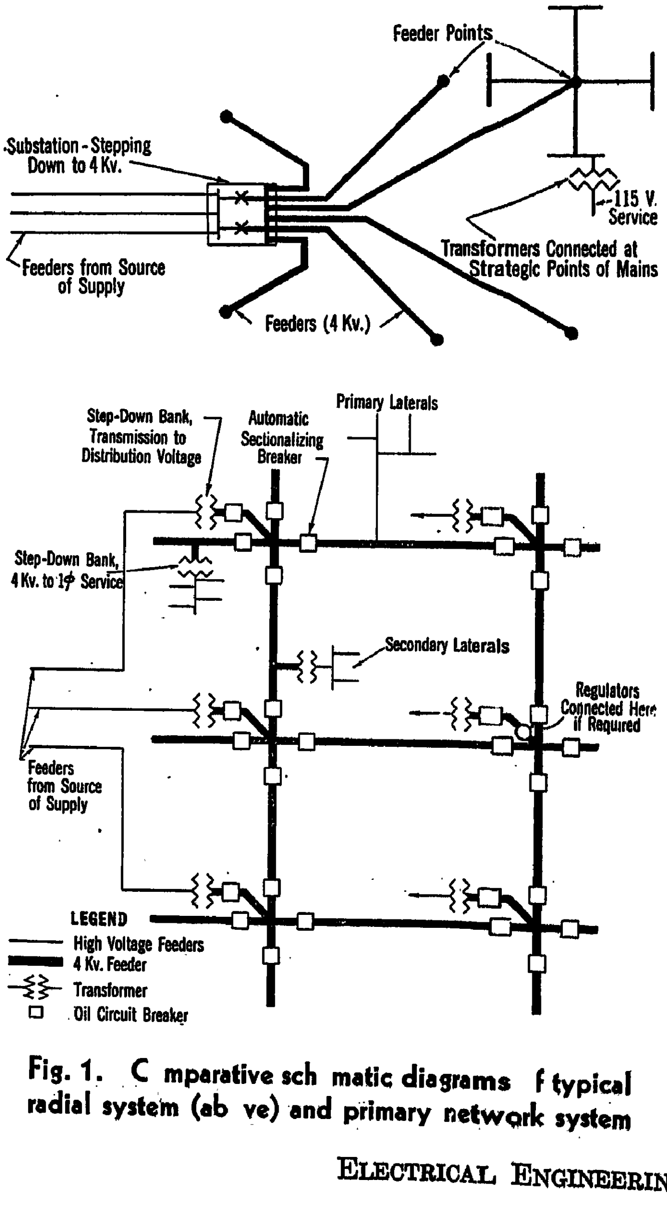
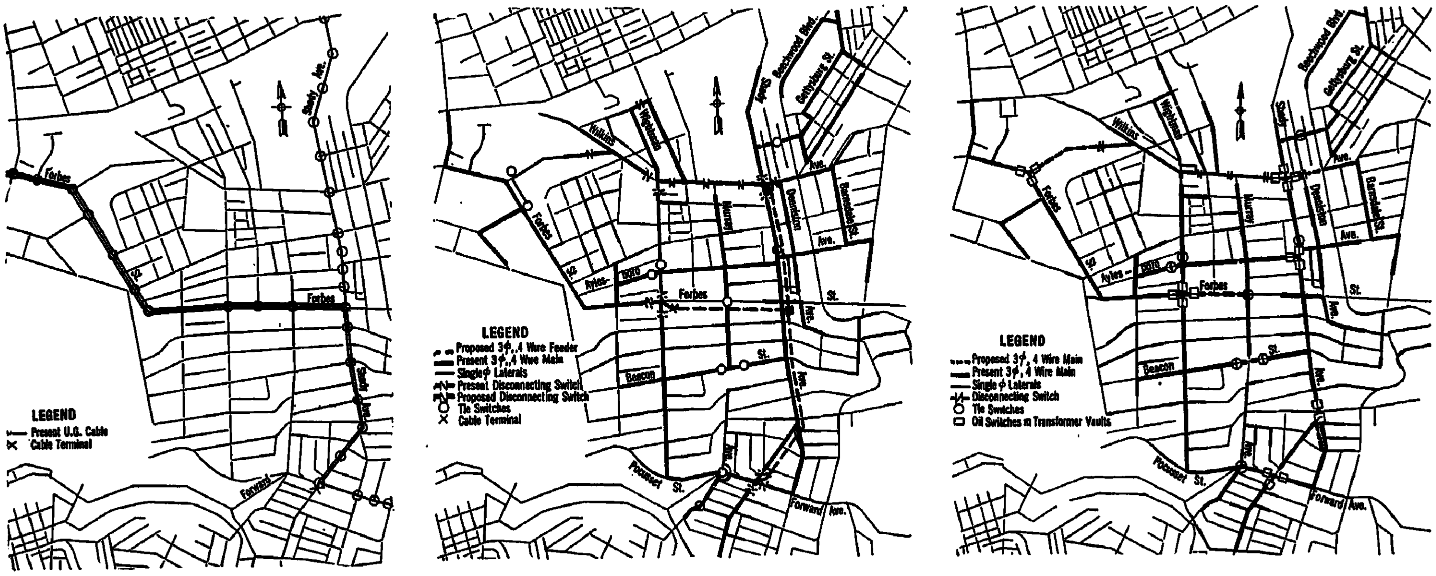

Feeder Points
Substation - Stepping Down to 4 Kv.
115 V. Service
Transformers Connected at Strategic Points of Mains
Feeders from Source of Supply
Feeders (4 Kv.)
Step-Down Bank, Transmission to Distribution Voltage
Automatic Sectionalizing Breaker
Primary Laterals
Step-Down Bank, 4 Kv. to 1φ Service
Secondary Laterals
Regulators Connected Here if Required
Feeders from Source of Supply
LEGEND
High Voltage Feeders
4 Kv. Feeder
Transformer
Oil Circuit Breaker

Fig. 1. Comparative schematic diagrams of typical radial system (above) and primary network system

---

From "The Primary Network," (No. 31-55) presented at the A. I. E. E. Middle Eastern District meeting, Pittsburgh, March 11-13, 1931.



Three transmission feeders available in the area to supply either system

Radial primary system which ordinarily would be used to supply the area

Diagram of mains for primary network showing distributed transformer points

Fig. 2. Radial versus network system for an area having a load density of 2,100 kva. per sq. mi.

COMPARATIVE COST ESTIMATES FOR AREA OF 2,100 KVA. PER SQ. MI.

To secure practical working data revealing the actual relative economies of the two systems, two different areas in the Pittsburgh district were studied exhaustively. Load growth in both areas required early attention to increased distribution capacity, and these comparative studies involved consideration of existing facilities as well as required extensions.

The initial study covered a residential section known as Squirrel Hill, which includes a few apartment houses and a small business district but no industrial load of any character. The area embraces about two square miles, has a winter peak load of some 4,200 kva., and a load density of 2,100 kva. per sq. mi. At present this area is fed by circuits from two adjacent areas; it was chosen for the initial economic study because (1) it had relatively definite boundaries and no existing substation and (2) load growth indicated the early necessity of extending the radial system materially or adopting a new system. (See Fig. 2.)

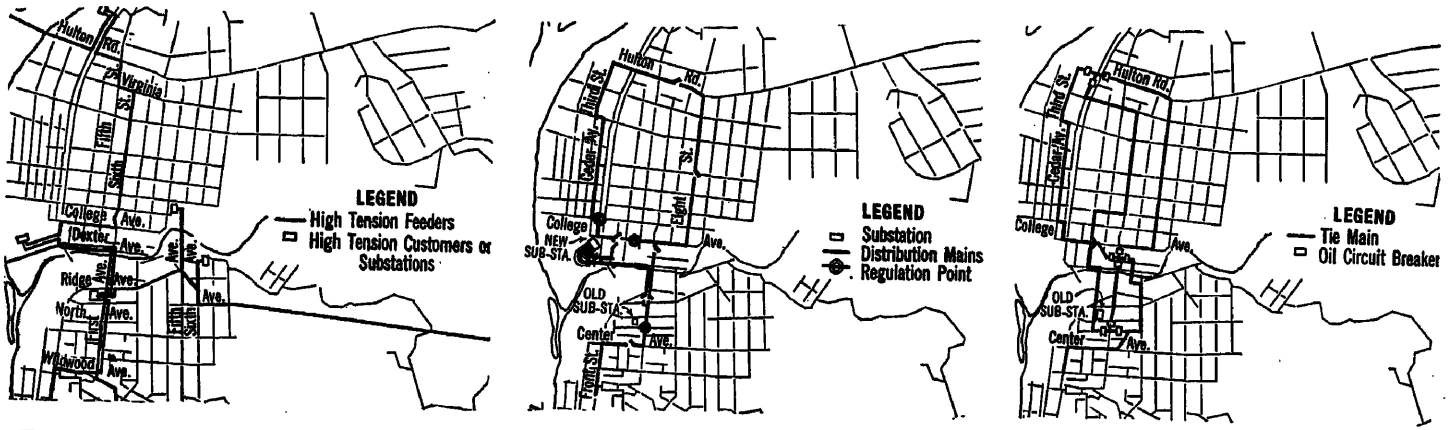
Estimates for extension of the radial system are based upon standard practise in the Pittsburgh district. The necessary substation proposed is a semi-outdoor 22/4-kv. full-automatic type similar to others on the Duquesne Light Company system. Its proposed location was chosen as the result of an economic study of the sites permitted by zoning ordinances, and is reasonably near the expected load center of the area. Initial installation would consist of two 4,000-kva. transformer banks, a 22-kv. tie breaker, three 300-ampere 4-kv. regulated feeders, and related equipment. The building would provide space for an ultimate of two 6,000-kva. transformer banks and five feeders.

The primary network includes exactly the same area and supply from the existing transmission feeders. Transformer and switching units contemplated are the submergible type planned for installation in street vaults. The transformers are 1,500-kva. 22/4-kv. three-phase units with four 2.5 per cent taps below 22-kv. and two similar taps above, and with a three-position disconnecting and grounding switch on the 22-kv. side. The transformer oil circuit breaker is integral with the transformer and comprises a 7.5-kv. 600-ampere unit rated at 14,000 amperes rupturing capacity at 4 kv., 2-OCO. The tie main breakers are similar and they will be arranged to reclose once on a fault, the breakers at each end of a faulty section closing at different times to provide the equivalent of two reclosings. Lead-covered cable is figured in for all 4-kv. work in the vaults and also duct connections between existing manholes and the proposed transformer vaults. Cables are planned to run in pipe from the vaults to the several poles at the related intersection, terminating there in disconnecting potheads.

Both the primary network and the radial plans provide for an operating capacity of 7,500 kva. Primary feeder and duct costs are common to both plans; hence were omitted from the comparison. Relative costs of the two plans as outlined are given in Table II where it may be noted that extension of the radial system will cost 78 per cent more than a change over to the primary network plan. The inherently better voltage regulation of the network is expected to obviate the necessity for regulators.

COMPARATIVE COST ESTIMATE FOR AREA OF 425 KVA. PER SQ. MI.

The Verona-Oakmont area was the second to be studied to determine the relative economies of the radial



Transmission feeders available in Verona-Oakmont area

Radial primary system which ordinarily would be used to supply the area

Primary network mains showing three transformer installations

Fig. 3. Radial versus network system for an area having a load density of 425 kva. per sq. mi.

versus the primary network system. In spite of the fact that the area embraces a total of 4.7 sq. mi. with a total load of only 2,000 kva., or a load density of some 425 kva. per sq. mi., the economies figured out so predominantly in favor of the network that the proposed substation was abandoned and the area converted to a 4-kv. primary network. The network construction is rapidly nearing completion. Also the area in question is of a residential character, with a light commercial load now served at 2.3 kv.

TABLE II—COST COMPARISONS FOR AREA OF 2,100 KVA. PER SQ. MI.

	Radial	Network
Initial Step		
Load	4,200 kva.	4,200 kva.
Transformer capacity installed	8,000 kva.	9,000 kva.
Transformer capacity with spare capacity out of service	5,000 kva.	7,500 kva.
	Costs in per cent	
Real estate	18.0	0.0
Substations	21.0	26.7
Electrical equipment	67.0	56.0
Transmission	1.2	1.5
Distribution	18.4	3.4
Ducts	4.7	10.8
Changes in 4-kv. feeders and mains	0.0	1.1
Total initial step	130	100
Second Step		
Load	7,500 kva.	7,500 kva.
Transformer capacity installed	12,000 kva.	9,000 kva.
Transformer capacity with spare capacity out of service	7,500 kva.	7,500 kva.
	Costs in per cent	
Substation increase	28.0	0.0
Distribution increase	20.5	0.0
Total second step	178	100

Note: Radial system (initial step) will have two 4,000-kva., three-phase, transformers. With one out of service, the other will carry 25 per cent overload through peak or 5,000 kva., which is satisfactory for initial step and allowing for growth.

Network will have six 1,500-kva., three-phase banks and when one transmission line goes out, two 1,500 kva., banks go out also, leaving 6,000 kva. in service which, with 25 per cent overload capacity, gives 7,500 kva. capacity to carry 4,200 kva. initial load.

In the comparative studies of the Verona-Oakmont area a new substation having two 3,000-kva. transformer banks (giving a rated station capacity of 3,750 kva. allowing for 125 per cent load on one bank with the other out) would be the minimum requirement for extension of the radial system. This system also would have required two 4-kv. regulated feeders. (See Fig. 3.)

For the same area the network plan was figured upon three different bases; with:

1. All equipment in underground vaults.
2. Equipment above ground in small buildings.
3. Equipment mounted above ground and outdoors on concrete pads.

Calling the cheapest of these methods (3) 100 per cent, data revealed that the radial scheme represented 35 per cent addition in cost. The underground vault network plan (1) and the small-building plan (2) figures respectively 18 and 7 per cent more costly than plan (3). Comparative data are given in Table III.

TABLE III—COST COMPARISONS FOR AREA OF 425 KVA. PER SQ. MI.

	Radial	Network		
		U. G. Vault	Bldg. Type	Outdoor
Load	2,000 kva.	2,000 kva.	2,000 kva.	2,000 kva.
Proposed inst. capacity	6,000 kva.	4,500 kva.	4,500 kva.	4,500 kva.
Operating capacity*	3,750 kva.	3,750 kva.	3,750 kva.	3,750 kva.
	Costs in per cent			
Real estate	17.0	0.0	2.8	2.8
Substation bldg. or vault	4.2	24.5	13.0	5.8
Equipment	95.0	71.0	66.3	66.3
Transmission	2.5	3.3	4.4	4.4
Distribution	1.6	13.2	13.2	13.2
Duct connections	14.5	5.7	7.5	7.5
Total†	135.	118.	107.	100.

*Based on 125 per cent load on transformers for five hours in case of feeder or transformer failure.

†Note: Cost of regulators included in above estimates.

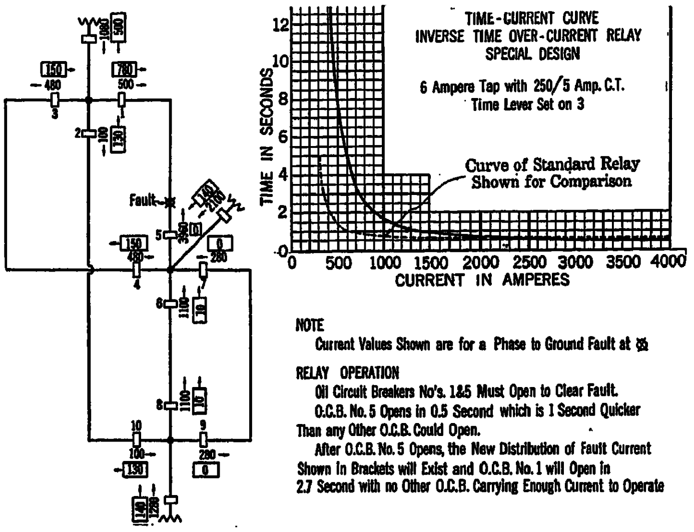
In pursuing the construction of the Verona-Oakmont primary network it was decided to use one each of the three kinds of installations just mentioned, in order to secure practical operating data. This worked out well because only three transformer points are required for the initial network. As to the future, it is contemplated that underground vaults may be used as required in congested areas where above-ground installations are out of the question because of proper costs or zoning ordinances. Small buildings may be used in less congested and medium-grade residential areas while in lower-grade areas the outdoor equipment on concrete pads and surrounded by a fence may be used to advantage.

In the area in question the vault will require submergible equipment. General details are revealed in the sketch, Fig. 4.

Relay Protection

Network relays similar to those used on low-voltage a-c. networks and providing similar protection are being used on the transformer breakers. Another relay recloses the breaker automatically upon resumption of supply on the feeder. Further protection in the form of a contact-making thermometer is being considered as a guard against protracted overloads. Bus differential protection at each transformer installation will operate to lock all breakers open in case of a fault on the bus at the intersection.

Tie-main protection has been the subject of extended investigation as a result of which overload relays with inverse-time characteristics greater than normally employed have been chosen for the service. With a 400/5-ampere current transformer and a 4-ampere relay tap, the relay will operate in 9 sec. at 480 amperes, and inaccurately on a current as low as 320 amperes. In the plan adopted only the two breakers connected to the faulty line will operate. However, if corner transformers are installed from which tie mains run in only two directions, proper selectivity is impossible with that particular transformer out of service. In general it may prove advisable not to use this design, but rather to run a third tie main to an adjacent intersection.



NOTE

Current Values Shown are for a Phase to Ground Fault at ⊗

RELAY OPERATION

Oil Circuit Breakers No's. 1&5 Must Open to Clear Fault.

O.C.B. No. 5 Opens in 0.5 Second which is 1 Second Quicker Than any Other O.C.B. Could Open.

After O.C.B. No. 5 Opens, the New Distribution of Fault Current Shown in Brackets will Exist and O.C.B. No. 1 will Open in 2.7 Second with no Other O.C.B. Carrying Enough Current to Operate

Fig. 5. Typical analysis of relay operation for tie-main fault

To determine definitely the requirements of a type of relay for this service, extensive short-circuit studies were

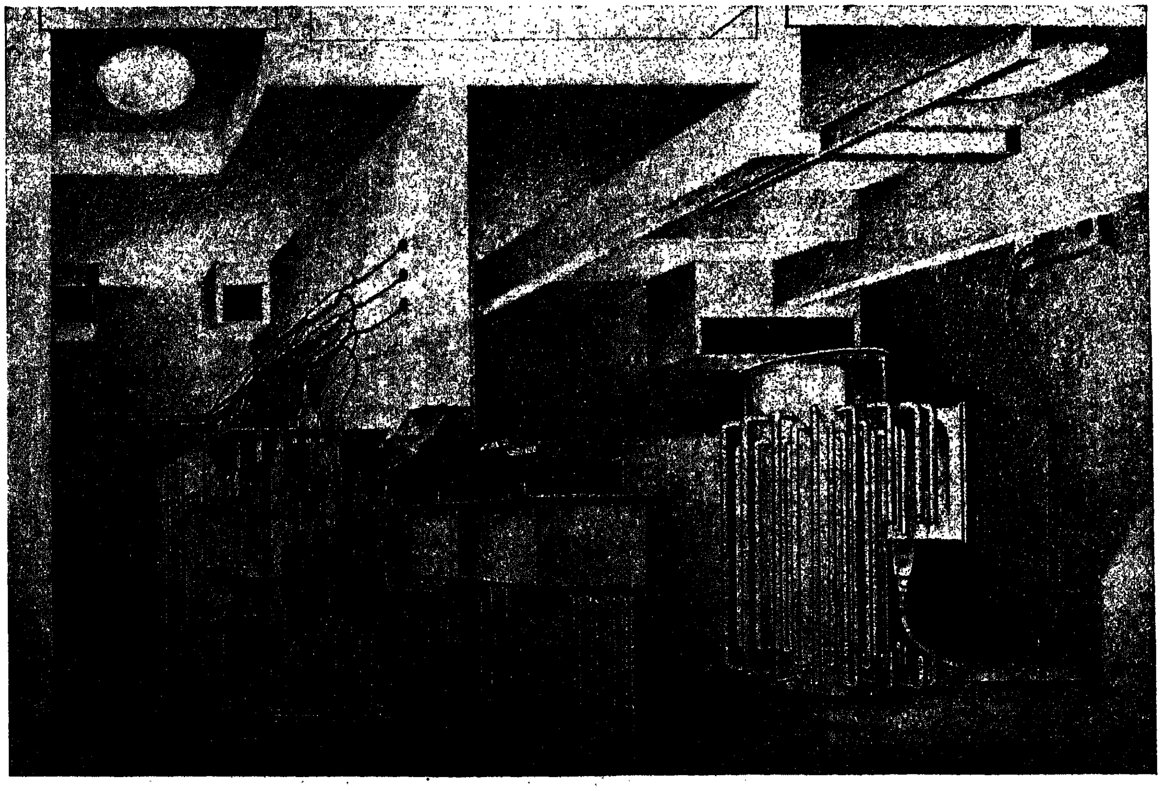


Fig. 4. Design features of underground primary-network vault showing barrier-wall construction for equipment segregation and showing also the integral construction of the transformer and its associated switching and relay equipment. Watertight hoods on (possible) regulators and watertight cubicles for breakers and all associated equipment also may be noted

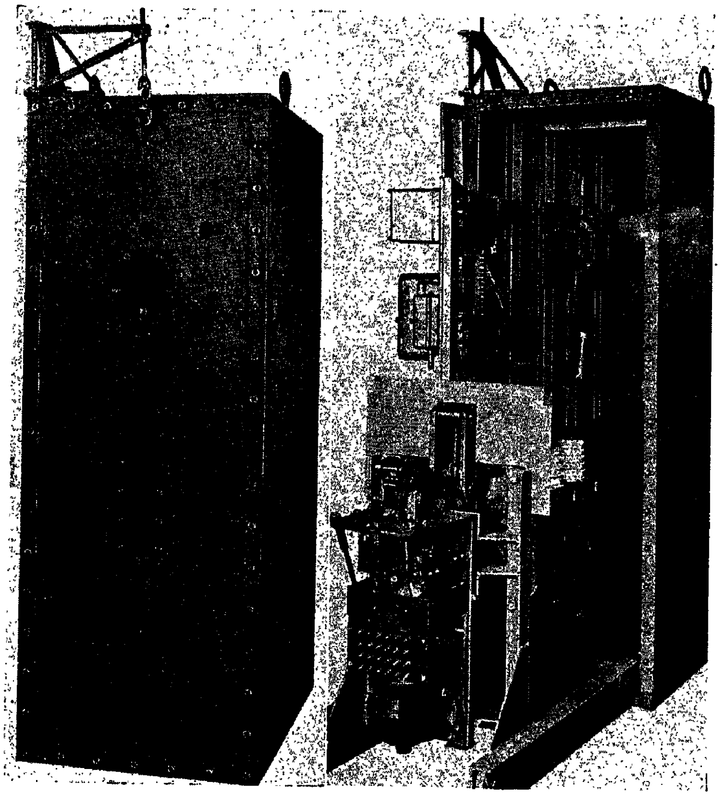


Fig. 6. Submersible cubicle for oil circuit breaker and associated equipment including relays

made of the network layout for three-phase and phase-to-ground faults at all locations along the tie mains, with all transmission feeders in service, and with each one out. Fig. 5 presents a typical analysis. Results in all cases are sufficiently conducive to warrant the expectation that no trouble will be experienced in relaying the Verona-Oakmont primary network, particularly if two-way-feed transformer installations can be eliminated.

CONCLUSIONS

On the basis of studies made, the primary network may be said to offer the following advantages over the usual radial system:

1. Material reduction in investment.
Even under the adverse conditions of load densities as low as 425 kva. per sq. mi., the cost runs as much as 35 per cent higher for the radial system.

2. Greater copper economy.
Reduced copper sizes are possible on the mains because of the smaller currents and shorter distances of feed, the results of the network principle.

3. Reduced duty on oil circuit breakers.
Short-circuit studies of the two areas studied and of theoretical systems indicate that the oil circuit breakers can be materially smaller than for the corresponding radial system.

4. Better regulation.
Any radial system inherently has considerable voltage variation which regulators cannot compensate. It is believed from a theoretical voltage analysis made that a very uniform voltage will be obtained on the network.

5. Small and standardized transformer units.
Transformer units (transformers, switches, regulators, if used, and auxiliary equipment), can be manufactured in units, stocked if necessary, and installed when required.

6. Capacity may be installed in small increments.
The radial system requires a substation and distribution system to be built well in advance of the load growth; long-range estimates are necessary for load growth both in direction and magnitude. In the primary network transformer units are installed where and when needed. Long-range predictions are unnecessary.

7. Investment for load growth in small increments.
The investment is not made in large steps far in advance of the load growth.

8. Reduced system losses.
One item of saving for example, is the complete elimination of feeder losses; there are no feeders.

9. Reduced area of outage.
With the designs considered each tie main will have a capacity of 600 or 700 kva.; the radial circuit has a capacity of 2,100 kva. A failure in the network therefore involves less than one-third the load of the radial system.

10. No 22-kv. breakers.
High-voltage cables run directly to the network transformers.

Vacuum Tubes and Their Applications

The extensive use of the high-vacuum tube in radio and communication work has resulted from certain remarkable characteristics of these tubes; the "thyratron" has been shown to possess certain other characteristics which mark it as being equally well suited to industrial uses.

By
W. C. WHITE
Member A. I. E. E.
General Electric Co.,
Schenectady, N. Y.

VACUUM TUBES may be classified according to (1) number of electrodes (a two-electrode tube, being termed a diode, a three-electrode tube a triode, and so on, to include tetrode and pentode); (2) content of the bulb, which may be high vacuum, gas, or vapor; (3) nature of the fundamental electrode, the cathode, which may be thermionic, photoelectric, mercury-pool, or cold.

For convenience, practically any form of the many types of vacuum tubes can be classified by a combination of these three properties. For instance one sold under the trade name of "tungar" is a gas-content, hot-cathode diode. Screen-grid tubes used so much in modern radio are hot-cathode, high-vacuum tetrodes. The small tubes which are sold under the trade name of "thyratron" are hot-cathode, mercury-vapor triodes.

HIGH-VACUUM TUBES

Fundamentally, the amount of current that can be carried through the vacuum in a hot-cathode, high-vacuum tube is dependent upon the electron emission and space charge effect. The electron emission is known to depend upon many contributing factors while the space-charge factor is controlled by simply introducing a grid into the tube with the proper voltage applied.

In a high-vacuum tube are embodied four features that singly or in combination make for a unique electrical device:

1. Independence of frequency.

The speed of electrons is such that they will respond to frequencies of the order of several million cycles per second, so that for most purposes the tube has no limitations in this respect.

2. Continuous control.

The electrons each carry such a small charge and are in such rapid motion that the current through the tube can follow accurately a very complicated wave form, as distinguished from the step-by-step action which occurs in most other electrical apparatus. This feature has made the high-vacuum tube useful in long distance telephony and radio broadcasting.

3. Voltage control.

Relatively large amounts of current through the tube can be controlled by the grid voltage without furnishing any current to the grid. For example, the electricity generated by rubbing a fountain pen with a piece of cloth, when applied to the grid is sufficient to control relatively large amounts of power. This feature provides for the high amplification common to this type of tube.

4. Rectification.

Current passes through the tube only when the cold electrode is positive with respect to the hot electrode.

From the point of view of these four factors, it may readily be seen why the high-vacuum tube is of such importance in radio. For industrial application, however, the high-vacuum tube has certain serious limitations, these being due mainly to high power loss within the tube. Part of this loss is represented by the power required to heat the cathode to the point at which electron emission will take place; this ranges from about 10 to 150 watts per ampere of current passed through the tube. Another limitation arises from the fact that from several hundred to about one thousand volts per ampere is required to force the current across the vacuum within the tube.

From these facts it will be seen that currents of more than a few amperes cannot be handled economically by means of this type of tube. Therefore, it is apparent that in the industrial field the most promising applications of the high-vacuum tube is in various control operations where the determining factor is the unique characteristics of the tube rather than its output.

THE THYRATRON

Next discussing the thyratron tube, its striking characteristics are the greatly decreased amount of power required to heat the cathode, and a marked reduction in the large voltage drop characteristic of the high-vacuum tube. This is brought about by the introduction of a slight amount of mercury gas or vapor into the bulb, the positively-charged vapor or gas molecules mingling with the electrons and neutralizing the space-charge. This neutralization of the space-charge makes possible a very different design of hot cathode; instead of utilizing what might be termed an open-type cathode permitting the electrons to leave the hot surface easily there may be used an enclosed-type cathode with just a few holes through which the stream of neutralized and negative ions may pass. This means that the heat may be kept within and conserved, whereas the electrons and positive ions may be allowed to travel to the anode. This is accomplished by surrounding the hot cathode with heat insulation and heat reflectors with only relatively small holes for the passage of the current. The resultant power loss is only about one watt per ampere of current through the tube contrasted with from 10 to 150 watts per ampere in the high-vacuum tube.

Also, neutralization of the space-charge eliminates the high voltage necessary to pass the current through the space; and instead of a large voltage increasing with the amount of current to be carried there is a constant-voltage drop of from 10 to 20 volts.

As a result a thyratron tube built to about the same physical size as the commonly-known UX-250 high-vacuum tube, and costing about the same amount to manufacture, will handle about 50 times as much current as the latter. It is apparent therefore, that the gaseous type of electrostatically-controlled tube is much better suited to the handling of relatively high currents common in the broad field of electrical engineering than is the controlled high-vacuum type.

Nevertheless, a thyratron tube has certain limitations; as stated, the high-vacuum type can handle currents up to a frequency of one million cycles per second, whereas the thyratron in its present form is limited to a few thousand cycles per second. Also the thyratron cannot control direct current in the same simple way as the high-vacuum tube; that is, it lacks the feature of "continuous control." These, however, are not serious drawbacks for most industrial uses and it appears that even as the characteristics of the high-vacuum tube fitted it remarkably into the radio communication field, so the thyratron tube may be considered equally well adapted for use in the industrial engineering field.

From a paper "Vacuum Tubes, Their Industrial Applications," presented informally at a meeting of the Schenectady Section of the A. I. E. E., Jan. 16, 1931. Reprints not available.

What are Effects of Electric Shock?

By
W. B. KOUWENHOVEN
Member A. I. E. E.
Johns Hopkins University, Baltimore, Maryland

O. R. LANGWORTHY
Non-member
Johns Hopkins University, Baltimore, Maryland

Are brain cells injured when currents do not pass through th head? What influence upon life continuity does the current path through the body have? In an effort to approach an answer to these and related questions a second set of experim ntal data is given herewith.

IT IS WELL RECOGNIZED that the point of bodily contact is a factor of great importance in cases of injury resulting from exposure to energized electric circuits. Physical danger to vital body tissues is the source of greatest danger to life continuity in cases of electric shock, and the location of the point of contact determines largely the pathway of current flow. Once inside the body the current spreads out in a more or less fusiform shape, but it is difficult to believe that the current density can be high in organs distant from the most direct path between points of contact. For example, if a man makes contact with an electric circuit through one arm and one leg, it is scarcely possible that any appreciable current will pass through his brain.

REVIEW

Before proceeding further with the present discussion it may be well to recapitulate briefly because earlier experiments reported upon[1] (for numbered references, see bibliography) brought to light certain facts which apply to the present series.

In the earlier tests electrodes were applied only to the head and tail of the animal subjects. Rats were used as the experimental animal and both continuous- and alternating-voltage shocks were administered at 110, 220, 500, and 1,000 volts. At each voltage the duration of contact at first was short and subsequently increased until it was impossible to resuscitate the subject by means of artificial respiration. These tests revealed that:

1. A 1,000-volt continuous current was more dangerous to rats than an alternating current of the same effective voltage.
2. A large rat survived a greater shock than a small rat.
3. Both sexes were equally susceptible to electric shock.
4. Paralysis of the hind legs resulting from hemorrhages in the spinal cord characterized many of the a-c. experiments.

With the electrodes on head and tail the brain was directly in the current path and the studies showed that the brain appeared to be injured readily by the passage of an electric current through it. Subsequent to the death of the rats evidences of nerve-cell damage and of both macroscopic and microscopic hemorrhage in the brain were found in many instances.[2]

In legal electrocution one electrode is placed on the skull, but industrial accidents rarely involve head contact; the common path is from hands to feet.[3]

RECENT EXPERIMENTS

The recent series of experiments was undertaken to study the influence of the current path upon the effects produced by an electric shock. Are injuries to brain cells produced when the current does not pass through the head? Rats again were chosen as animals for study because of accurate knowledge of their behavior and because a rat seldom if ever dies of damage to heart after an electric injury, but rather from respiratory failure. Using a 1,000-volt circuit, 102 rats were shocked, half with a-c. and half with d-c., each for a period of two seconds. Electrode positions were varied and a few tests were made with the electrodes on the head and tail of the animals to check the results of the prior series.

Preparatory to the shock the rats were given ether until they were quiet, then the points of contact were moistened thoroughly with saline solution and the electrodes (voltmeter clips filed smooth) attached. When connection was made to the head a special electrode was employed which made contact only on the upper surface of the skull and did not interfere with breathing. After the electrodes were in place the shock was applied. In each case the circuit was held closed for exactly two seconds and the current flowing through the animal was recorded.

Immediately following the shock, the animal was removed from the circuit and if there was no evidence of breathing, artificial respiration was applied. This consisted of the application of digital pressure upon the chest, reproducing so far as possible the Schaefer prone-pressure method. Also the tongue was pulled out, the vagus nerves in the neck were stimulated by stroking with the fingers, and efforts were made to keep the respiratory tract free from mucus.

Following the a-c. injuries the chest of the animal was fully expanded, a seemingly important aid to the resumption of spontaneous breathing or to adequate artificial respiration. However, after contact with the d-c. circuit the chest was collapsed and it was difficult to get air into the lungs. The a-c. shocks produced a strong contraction of musculature of the body and this in the cases of males was accompanied almost invariably by an emission. Clonic movements of the muscles of the leg were observed in many of the a-c. injuries, probably produced by irritation of the nerve cells due to asphyxiation. Bleeding of the conjunctiva also occurred in many cases.

ELECTRODES ON HEAD AND TAIL

Six rats in the present series and ten in the prior series were subjected to a two-second contact with a 1,000-volt a-c. circuit with electrodes affixed to head and tail. Artificial respiration was required and applied in 88 per cent of the cases, and five or 31 per cent recovered. The others died or were paralyzed by the shock. Three of the five that recovered were normal. After breathing was established it was rapid, shallow, and somewhat irregular for several hours following the injury, later becoming normal.

Only one of the six rats in the present series was paralyzed as against five of the ten in the prior series; in fact in the present group paralysis was less common and fewer hemorhages in the spinal cord were found than in the tests of a year ago although no explanation for the discrepancy can be given. A brief analysis of tabulated results shows that:

1. Of the five subjects to recover, the average weight was 217 grams and the average body current 0.848 ampere.
2. Of the six paralyzed subjects, the average weight was 242 grams and the average body current 0.800 ampere.
3. Of the five subjects which died, the average weight was 161 grams and the average body current 0.844 ampere.

In the tests previously published no rat survived a contact of one second or more with a d-c. circuit of 1,000 volts. Therefore, in this series only two animals were given a two-second shock at this voltage and neither of them survived although their hearts beat strongly for several minutes following the contact. Autopsy showed only few abnormalties, but microscopic examination of the brains of the rats of the prior series revealed that the current had caused nerve-cell injuries incompatible with life.

Observations in the present group check with those of the prior experiments where the electrodes were applied to the head and tail of the animal. It is clearly evident that contact with a 1,000-volt d-c. circuit is much more deadly to a rat than contact with an a-c. circuit of the same effective voltage. In this series, artificial respiration was applied to all of the animals tested with continuous current, and 100 per cent of them died. In the a-c. tests, however, artificial respiration was needed in only 88 per cent of the cases; 31 per cent of the animals died, 38 per cent were paralyzed, and 31 per cent recovered from the injury.

ELECTRODES ON RIGHT FORE LEG AND TAIL

Twelve rats were given a two-second 1,000-volt a-c. shock with electrodes on the right fore leg and tail. Five of these rats breathed as soon as the circuit was opened; in the other seven cases artificial respiration was required. Death occurred either immediately or within a few minutes in 42 per cent of the cases; three rats were paralyzed, one of which died four hours after the injury, another, nine hours, and the third survived until killed preparatory to autopsy.

This group was of particular interest in emphasizing the fact that an animal was not necessarily on the road to recovery when breathing was first started. This phenomena is mentioned often in records of human electric shock. Breathing was started in three of the rats only to cease after a few minutes and a second application of artificial respiration saved only one. Several of the rats in this group were hyper-irritable to all sensory stimuli for some minutes following the injury. Bleeding from the eyes was a common occurrence. The paralyzed rat that survived had a hemorrhage in the spinal cord and there was no chance of its permanent recovery.

With the alternating current flowing through the animals from right fore leg to tail 35 per cent of them recovered, 42 per cent died, and 25 per cent were paralyzed. The injury was slightly less severe than when the brain formed part of the current path as in the previous series.

Another twelve rats were tested on a continuous-current circuit with electrodes also on the right fore leg and tail. In this test the brain did not lie directly in the path of the current and the results were vastly different from those where one contact was made with the top of the skull. Here six of the rats breathed spontaneously when the circuit was opened, whereas none were saved in the first series even after long applications of artificial respiration. There was only one rat in this group of twelve that did not attempt to breath after the injury.

Artificial respiration was applied in 50 per cent of the d-c. cases; 42 per cent recovered; 25 per cent died, and 33 per cent were paralyzed; but these figures do not tell the whole story. Burns resulting from contact with direct-current were much more severe than those observed with alternating current. Because of these burns it was not possible to keep any of the surviving animals alive for a period longer than three days following the d-c. shock. However, any rat that survived an a-c. shock without paralysis appeared quite normal 24 hours later; they ate, drank, and were active. It is of interest also to note that in this d-c. group there were two cases where breathing was started only to stop again. In both of these instances a second application of artificial respiration was unsuccessful. Further brief analysis of tabulated results of this group of tests involving 24 rats shows that:

1. Of the four subjects which recovered from a-c. shock the average weight was 171 grams and the average body current 0.767 ampere; of the five recoveries from d-c. shock, 108 grams and 0.754 ampere.

2. Of the three subjects paralyzed by a-c. shock the average weight was 179 grams and the average body current 0.743 ampere; of the four paralyzed from d-c. shock, 130 grams and 0.887 ampere.

3. Of the five subjects dying from a-c. shock the average weight was 174 gram and the average body current 0.718 ampere; of the three succumbing to d-c. shock, 103 grams and 0.800 ampere.

From these results it is clearly evident that in cases where the continuous-current path does not include the brain there is at least a fifty-fifty chance of resuscitating the animal.

ELECTRODES ON LEFT FORE LEG AND TAIL

Twenty-four rats were tested with the electrodes on the left fore leg and the tail, half with alternating and half with continuous current. Under alternating current, artificial respiration was applied in 75 per cent of the experiments; 58 per cent recovered, 17 per cent were paralyzed, and 25 per cent died. With direct-current, artificial respiration was used in only 58 per cent of the cases; 42 per cent recovered, 33 per cent were paralyzed, and 25 per cent died.

The results of this series also emphasized the fact that breathing will not necessarily continue after having been established either spontaneously or by artificial respiration. Reactions and behavior of the rats in this group were closely identical with those where the current path was from the right fore leg to the tail. It was not, however, quite so dangerous to life. The d-c. results here also confirm the importance of eliminating the brain from the current path if any hope of recovery for the animal is to be entertained.

ELECTRODES ON BOTH FORE LEGS

Eight rats were tested with electrodes on both fore legs, thus involving the heart and lungs directly in the path of the current flow; four were shocked with alternating, and four with continuous current; their average weight was 144 grams and the average body current was 1.24 amperes.

Although artificial respiration was tried in every case, no animal survived, a fact not strange when one considers the current that flowed for two seconds. The chest was warm to the touch when the circuit was opened. In all but one case, however, the heart continued to beat following the shock. It is remarkable that there was any heart beat at all after so severe an injury, and that two of the rats attempted to breathe following the a-c. contact and two following the d-c. contact. There is no possibility of survival with this current path.

ELECTRODES ON BOTH HIND LEGS

Fourteen rats were tested at 1,000 volts with electrodes attached to both hind legs, seven on an a-c. circuit and seven on a d-c. circuit. Their average weight was 127 grams and the average current that flowed for two seconds was 1.17 amperes. Only one rat died as a result of the a-c. contact, and two from the d-c. contact, when the circuit path involved principally the caudal region of the body. The rat that died after the a-c. contact had started breathing spontaneously as soon as the circuit was opened. He was considered as recovered and had been placed back in the cage; ten minutes later he was found dead.

Artificial respiration was not applied to any of the seven rats that were injured with alternating current. All breathed spontaneously and 86 per cent recovered completely. They were all active and lively within a few minutes following the shock. One, or 14 per cent, died, and it is believed that his life could have been saved had artificial respiration been applied at the proper time. Following the d-c. shock, five of the animals breathed at once. Artificial respiration was applied in but two cases, (29 per cent) and these animals died after a few attempts at breathing. The other five (71 per cent) recovered and in a few minutes became very active.

These tests demonstrate clearly the fact that when none of the vital organs lie directly in the path of body current the electrical injury usually is small.

ELECTRODES ON ONE FORE LEG AND ONE HIND LEG

Effects produced by the flow of current from the right fore leg to the left hind leg were studied in eight rats, from the left fore leg to the left hind leg in eight other rats, and in a third group of eight the electrodes were on the left fore leg and the right hind leg. Half of these were subjected to an a-c. circuit and the remainder to a d-c. circuit.

Not a single rat was permanently saved after contact with the d-c. circuit; one was resuscitated but only to die two and a half hours later. In several cases no heart action could be detected and at most, many of the animals gave only a few gasps. There was greater success in saving those that had been injured with alternating current, where in five cases breathing was established by a long application of artificial respiration. One of this five was paralyzed, but all including the paralyzed one became quite active soon after the shock.

Results for the 24 cases where the current path was from fore to hind leg, may be summarized as follows:

1. Artificial respiration was applied in every instance, both for the a-c. and d-c. contacts.

2. With alternating current 33 per cent of the animals recovered, eight per cent were paralyzed, and 59 per cent died.

3. With continuous current 100 per cent of the animals died.

4. Of the four subjects which recovered, the average weight was 116 grams and the average body current 0.910 ampere.

5. The rat that was paralyzed weighed 143 grams and the current that flowed was 1.060 amperes.

6. Of the nineteen subjects which succumbed, the average weight was 132 grams and the average body current 1.211 amperes.

Normally one would expect that there would be little if any difference between the effects produced by a current flowing from either fore leg to tail or by one flowing from either fore leg to either hind leg; yet in the group where the current path was from fore leg to tail, 44 per cent of the rats recovered; in the second group where one electrode was attached to a hind leg instead of the tail, only 16 per cent were saved.

Wherein, then, lies the deadliness of this current path from fore leg to hind leg? The authors believe that the high death rate found here is caused by the low-resistance path that the animal offers to a current flow when its tail is eliminated from the circuit. The average resistance of the current paths from fore legs to hind legs for the 24 rats was less than 70 per cent of that found for the 48 rats where the current paths were from either fore leg to tail. The higher resulting current is believed to be responsible for the deaths of the animals. A second argument supporting this conclusion is the almost complete absence of serious injury to the rats when the current passed from one hind leg to the other, even though the current values were high.

DISCUSSION AND CONCLUSIONS

These experiments confirm Urquhart's[4] conclusion that when an electric current passes through the brain a temporary physiological block is produced in the respiratory center and that spontaneous breathing ceases for a time. He stated that if no serious injury to the heart occurs, adequate artificial respiration may give time for the center in the medulla to recover and for normal breathing to begin. Maclachlan[3] reports in his field notes a case of recovery from shock following eight hours of continuous application of the Schaefer prone-pressure method, which also confirms Urquhart's findings. Urquhart[5], in a second series of experiments, demonstrated that a temporary block could be produced in the spinal cord or in a nerve trunk by the passage of an electric current.

Langworthy[2] found by his microscopic examination of sections of the brains of the rats injured by high-voltage electric currents that in many cases the damage to the cells was incompatible with life. Microscopic study of the central nervous systems of all of the rats in this present series will be made.

Results obtained clearly demonstrate the presence in many of the rats of a temporary respiratory block, the location of which, whether in the brain stem or in the vagus nerves, depends upon the current path. Resuscitation is possible provided the damage done does not require a recovery time too long to permit life to be supported in the interval.

Effects produced by the various current paths through the animals are summed up in Table I. From that table and from the results presented, the following conclusions may be drawn:

1. A 1,000-volt continuous-current circuit is more dangerous to rats than an alternating circuit of the same effective voltage, irrespective of the current path.
2. The chances of recovery are best when the brain does not lie directly in the pathway of the current.
3. The injury produced by the current path from the left fore leg to the tail is less severe than that caused by the same current flowing from right fore leg to tail.
4. When the main pathway of the current did not include the brain, spinal cord, or nerves required for respiration, most of the animals breathed at once and were active a few minutes after the injury.
5. The presence of a respiratory block has been demonstrated, and the fact that when natural breathing is first established the animal is not necessarily on the road to complete recovery.
6. The respiratory block is less severe, if not absent, when the current traverses the posterior portion of the body.
7. Burning of the tissues with continuous current is much more severe than occurs for the same effective alternating current.

TABLE I—SUMMARY OF RESULTS OBTAINED IN EXPERIMENTS
Submitting 161 Rats to Contact with 1,000-Volt Circuits for Two-Second Shock Periods

Current	Position of electrodes		Number shocked	Per cent requiring artificial respiration	Per cent immediate recovery	Per cent paralyzed	Per cent immediate death
Alternating	Head	Tail	16	88	31	38	31
Continuous			3	100	0	0	100
Alternating	Right fore leg	Tail	12	58	33	25	42
Continuous			12	50	42	33	25
Alternating	Left fore leg	Tail	12	75	58	17	25
Continuous			12	58	42	33	25
Alternating	Either fore leg	Tail	24	67	46	21	33
Continuous			24	54	42	33	25
Alternating	Right fore leg	Left fore leg	4	100	0	0	100
Continuous			4	100	0	0	100
Alternating	Right hind leg	Left hind leg	7	0	86	0	14
Continuous			7	29	71	0	29
Alternating	Either fore leg	Either hind leg	12	100	33	8	59
Continuous			12	100	0	0	100

BIBLIOGRAPHY

1. EFFECT OF ELECTRIC SHOCK, by Kouwenhoven and Langworthy, A. I. E. E. TRANS., Jan. 1930, Vol. 49, p. 381.

2. ABNORMALITIES PRODUCED IN THE CENTRAL NERVOUS SYSTEM BY ELECTRICAL INJURIES, by Langworthy, *Journal of Experimental Medicine*, Vol. 51, p. 943.

3. ELECTRIC SHOCK—INTERPRETATION OF FIELD NOTES, by Maclachlan, Wills, *Journal of Industrial Hygiene*, 1930, Vol. 12, p. 291.

4. EXPERIMENTAL ELECTRIC SHOCK, by R. W. Urquhart, *Journal of Industrial Hygiene*, 1927, Vol. 9, p. 140.

5. EXPERIMENTAL ELECTRIC SHOCK, II, by R. W. Urquhart and E. O. Noble, *Journal of Industrial Hygiene*, 1929, Vol. 11, p. 154.

Electric Power in the Steel Industry

A brief outline of some of the revolutions in production methods brought about by electrification on a large scale.

By
G. E. STOLTZ
Member A. I. E. E.

Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

SINCE the World War practically every industry has been subject to a declining market price of its commodity. The very definite problem before industry during this post-war period has been to modify production methods and processes in a manner which will permit the manufacture of commodities at a constantly declining cost.

Perhaps in no industry has there been greater progress in recent years than in the steel industry and some of the major advances that are attributable to the application of electricity, not only to auxiliary drives and annealing processes but also to the replacement of the large steam engines for main roll drive with motors, far exceed in performance and output anything obtainable by steam. Perhaps even more vital than the application of motors to main rolls has been the installation of delicate and accurate control devices which has brought about a complete change in the rolling of steel.

Up to 1921 the steel industry had been accepting electrification but not in the wholehearted manner as it now does. As to main rolling drive, there was considerable argument between the steam advocates and those who were in favor of electric drive; but when the steel industry was definitely confronted with a steady decline in the price of steel products the curtain was drawn abruptly on further debate and many large engines were replaced by electric drives. At that time an electrified plant enjoyed an advantage of $2.50 per ton of product over a steam-driven plant; at present this difference is even greater.

One of the first products to feel the far reaching effects of electrification was strip formerly rolled in mills where the metal was passed back and forth by hand from one stand to another. The drawback in this type of mill was not only that it required a great amount of hard labor but that the thin metal traveling along the cold floor would lose its temperature rapidly. The tandem motor-driven mill arrangement not only reduced the amount of power required to roll the steel but enabled the same slab to be finished to a thinner gage.

So long as steam engines were used this newer type of tandem mill of course was impossible because it is necessary to have, for the driving of each stand, individual units which can be adjusted in speed to accommodate different drafts in individual stands and maintain a pre-set speed whether the load be light or heavy.

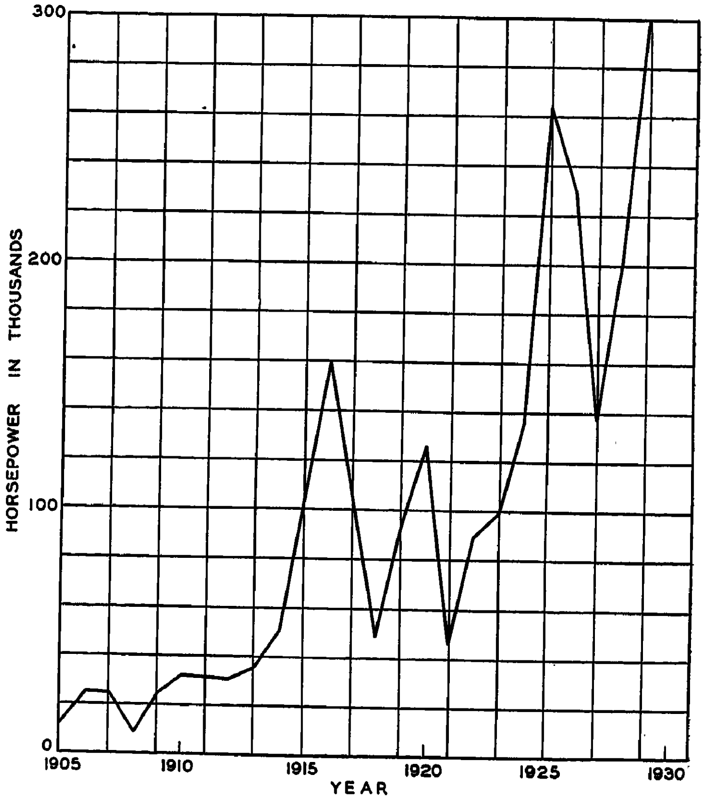


Fig. 1. Installed horsepower on main-roll mill drives is increasing rapidly

Strip usually covers a range from 3 to 20 inches in width while sheet varies in width from 30 to 60 inches. Since the continuous type of individual motor-driven mills proved so successful in strip mills it is only natural that present day production of heavy sheets is being drastically changed. The transition has not reached

---

From "The Use of Electricity in the Steel Industry," presented at the Western Metals Congress, San Francisco, Feb. 16-21, 1931.

that same conclusive state as it has in strip mills and at the present time only the heavier sheets are being rolled on this type of mill. It is possible however that in the near future continuous rolling of sheet will be almost as complete as the continuous production of strip.

From sheet to plate is the next logical step; consequently the first installation of a continuous plate mill is being made now. In other words the use of the tandem-mill motor specially designed for flat speed regulation has gone from strip to sheet mills and now is invading the plate-mill field. In general, the old type of mill was able to produce from 10,000 to 15,000 tons per month.

Recently with the development of structural shapes has come a new type of wide-flange mill where motor drive has been utilized. In the rolling of these larger and relatively more complicated shapes only the advent of sensitive, sturdy, and accurate automatic electrical control devices has made the wide-flange mill an operating success. In one mill typical of this a 7,000-hp. motor drives the main rolls (used on the web and inside flanges of a beam) and also two vertical rolls which reduce the outsides of the flanges. Adjacent in the line of production is a set of auxiliary horizontal rolls which reduce the edges of the flanges. These auxiliary rolls are driven by a 2,000-hp. motor. It is essential that these two motors remain in synchronism regardless of the relative load on either of them. Also, with the material passing back and forth between these three sets of rolls and with the different drafts to be taken on the rolls, various speed relations between the three sets of rolls must be pre-set and rigidly maintained for any given pass. This represented one of the difficult problems in the design of the electrical equipment for this mill. It not only required a careful designing of the control but of the motor as well.

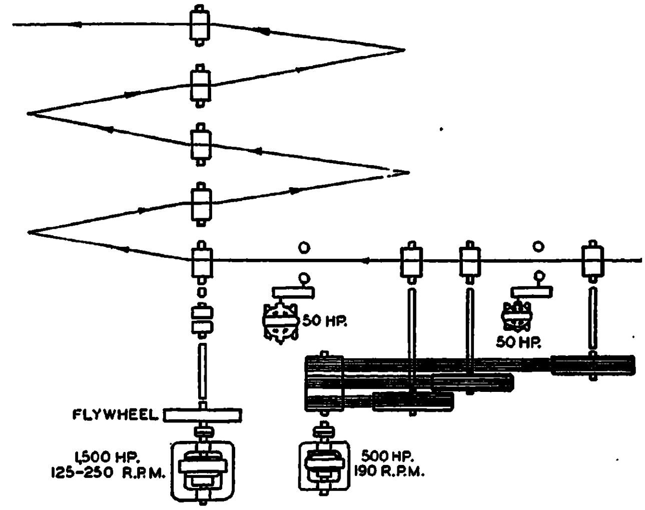


Fig. 2. Layout of typical older type of 14-in. strip mill showing hand transfer between finishing stands. Compare with Fig. 3

The other problem was to establish a proper setting for the three sets of rolls as the metal was being reduced from a beam blank to a finished beam. It may be imagined that if heavy drafts were taken in the vertical rolls during the early passes, while most of the work to be done by the main horizontal rolls was delayed to the last few finishing passes, there would be considerable distortion and unnecessary strain set up in the metal. With three sets of rolls to be adjusted after each pass it was inconceivable that two men would reproduce properly the drafts as each piece of metal came through the mill, a matter of importance in securing uniform elongation of the metal throughout its entire section; further, unless drafts could be predetermined it would be impossible to pre-set the speed of the 2,000-hp. motor. For this reason arrangements were made to operate the screwdown on the three sets of rolls automatically for each individual pass and at the same time adjust the field of the 2,000-hp. motor for its correct speed. This automatic setting of the rolls for each individual pass was the second distinct contribution made to the phenomenal success of this type of mill by electrification.

FUTURE PROSPECTS

There are many other instances where the steel industry has utilized electrification to maintain a prosperous condition regardless of the decline in the price of steel. Probably one of the most spectacular changes from a labor point of view is in the production of wrought iron. At the present time one company is incorporating a method of manufacturing wrought iron by merely pouring the molten iron from one ladle into another containing molten slag. In three minutes a three-ton ingot is produced by a few men, whereas by the old method it took twenty men two hours. The old method of puddling might be termed a back-breaking job meant for young men only; today the seasoned man of fifty with steady habits is better adapted to manipulate the machinery required for this new process.

There is no question but that still further changes of great consequence to steel production will be obtained through the use of electricity. As yet there is little appreciation of the full use to which electricity may be placed, but these possibilities will be unfolded in the future just as they have been in the past.

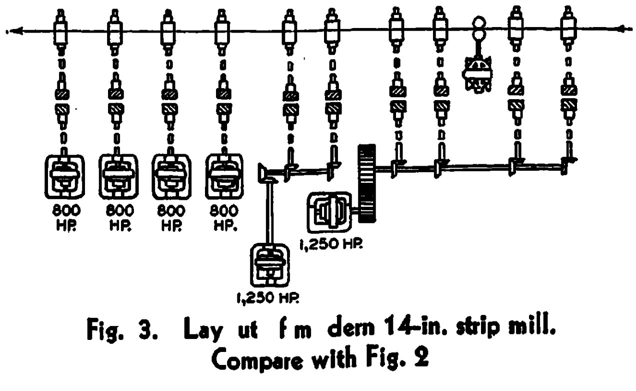


Fig. 3. Layout of modern 14-in. strip mill. Compare with Fig. 2

A Neutralized Welding Generator

By reducing the magnetic energy stored in the generator field, transient currents in d-c. welding machines can largely be eliminated. Providing such generators with neutralizing windings reduces this energy to a minimum.

By
F. CREEDY
Member A. I. E. E.

Lehigh University
Bethlehem, Pa.

ARC-WELDING generators of the d-c. type in order to be satisfactory not only must operate at constant current over a wide range of voltages, but must also be free from heavy transients. The operation of such machines can be improved vastly by incorporating in their design a winding to neutralize the effect of armature reaction in the generator, and a high external reactance in series with the arc.

It should be noted at the outset that two different types of welder are possible—the separately-excited type and the shunt type. The former type has a separately-excited coil in its field, its ampere-turns opposed by a coil connected in series with the armature; the shunt type, in addition to this, has a shunt coil on the field.

It is proposed that in the case of a shunt type of welder its shunt coil and separately-excited coil should be combined into one in the manner shown in Fig. 1. If to a shunt coil and a separately-excited coil, each of resistance R, are applied voltages E_1 and E_3 respectively, the currents in each will clearly be E_1/R and E_3/R. If instead of this a single coil is used, still of resistance R, and is submitted to an e. m. f. equal to $E_1 + E_3$, then the current will be $E_1/R + E_3 R$; that is, the ampere-turns will be just the same as in the case of the two separate coils. This construction provides a minor simplification in the design of this particular type of machine. Its chief advantages, however, are that by rendering leakage between the shunt and separately-excited windings impossible (since they are now the same winding), it reduces transient currents and prevents damping of the shunt currents by the separately-excited winding.

In any study of welder design, a careful consideration of transient characteristics is of the utmost importance. Although the steady characteristics of a welder may show a constant current for a wide range of voltage, if transient variations from these conditions are possible, the machine still will be unsatisfactory.

If the current is capable of a sudden jump from one value to a higher one, then any sudden shortening of the arc or contact with the work means that an excessive amount of energy is suddenly concentrated in it, resulting in an explosion with the familiar "spluttering" so annoying to welders. This spluttering is almost entirely the fault of the generator.

It will be clear now that the steady characteristic of the generator (for instance as measured on a resistance load), does not indicate whether it is good or bad for welding purposes. It must have an additional quality which is vaguely called stability; which brings up the question as to how this stability may be calculated and measured?

It is proposed that the stability of all welding apparatus be defined in terms of what may be called the "stability ratio," and that the stability ratio be defined and measured by (1) applying full load to the welder by means of a resistance, as for example, 200 amperes at 30 volts; (2) by arranging a switch so that the resistance may be short-circuited instantly thereby instantly short-circuiting the terminals of the machine through the steadying reactance; and (3) by measuring the maximum current kick produced (600 amperes for example) when the short-circuiting switch is closed. The stability ratio is then the ratio of this maximum kick to the normal full-load current.

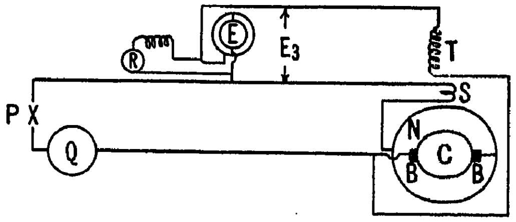


Fig. 1. Schematic diagram for neutralized welder

The shunt and separately-excited fields have been combined in a single winding T. The neutralizing winding is designated at N while Q represents the arc series reactance

In the example given, where the kick is 600 amperes and the full-load current 200 amperes, the stability ratio is 3. Under a small stability ratio the welder will operate steadily.

There is no serious difficulty in measuring this kick by well-known methods with instruments ordinarily found in a test room: First the glass front is removed from an ammeter, preferably one of the moving-coil or dynamometer type whose moving system has a low moment of inertia. By means of a pencil point, or otherwise, the needle is held at approximately the value

---

From "The Neutralized Welder—A Means of Controlling Transients," (No. 31-31), Presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

which the current is expected to have—say 600 amperes. Next, the machine is short-circuited, and if the current is less than the value indicated by the pointer, it will continue to rest against the pencil point and be prevented from moving back to zero. If the current is greater, the needle will momentarily flutter away from it to a greater or less extent. If, however, there is no flutter, the test should be repeated with the needle held opposite a lower reading on the scale, say 500 amperes. If the flutter is vigorous, the needle should be held opposite a higher reading on the scale, for instance 700 amperes—the test being repeated until a point is found where the needle shows only a slight indication of movement. By this means, using only standard d-c. instruments, the instantaneous short-circuit current may be measured with fair accuracy.

It is necessary that the voltage of the generator be able to respond rapidly to changes in arc length while the current remains constant; it would seem therefore that the separately-excited type of generator in which no voltage variation whatever can take place unless there is current variation must be inferior to the shunt type in which voltage and current variation are independent of one another. Up to a few years ago this reasoning was common but since as hitherto designed the shunt type of machine was found to be sluggish—that is, the voltage did not rise sufficiently fast with increasing arc length—it has fallen into disrepute.

After a rather complete mathematical study of welder transients it was concluded that this sluggishness arises from the large amount of magnetic energy stored in the field system of machines of ordinary design. For instance when the voltage increases, the flux of the machine must increase also; and if this requires a large increase in magnetic energy, then a certain amount of time must elapse before that energy can flow in. The proposal outlined in the beginning provides that the magnetic energy stored in the field system be reduced to a minimum. Again if there is leakage between the series and the shunt or separately-excited coils, or to borrow a term from radio practise, they are "loosely coupled," the transient current in the separately-excited coil is not closely conditioned by current changes in the series coil.

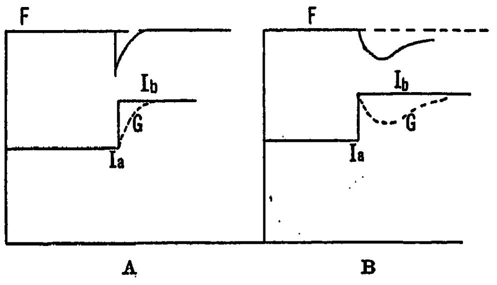


Fig. 2. Current diagrams for a generator with small field leakage (A) and high field leakage (B)

I_a and I_b represent the welding current, F the current in the separately-excited coil, and G the resultant ampere-turns

The foregoing is illustrated in Fig. 2; in the case of small leakage as shown at A, when the welding current rises from I_a to I_b, the increased ampere-turns of the series coil are instantaneously masked by equal and opposite ampere-turns in the separately-excited coil whose current is shown at F; if the energy stored in this circuit is small, these transients die away at an exceedingly rapid rate so that the flux very rapidly takes up its new value. With high leakage as shown at B, the change in the ampere-turns in the series coil immediately influences the flux, since the transient currents in the separately-excited coil have considerable lag. Later the transient current in the separately-excited coil starts causing the flux to return to nearly its original value after which the transient gradually dies away, the net effect being that the flux first falls, then increases, and then gradually falls again—a very undesirable condition. Hence, one may summarize the condition which leads to good transient characteristics in a welder by stating that there should be "close coupling" between the series and shunt or separately-excited coils. It has been shown that under this condition both the magnetic energy and the leakage should be small.

In Fig. 3 are shown oscillograms of welding current for a welder whose field windings are separate and those for a welder arranged as shown in Fig. 1. By comparison of these two curves it is obvious that the initial rise of current which is universal in welders whose transient characteristics have not been carefully studied, is entirely absent in welders designed as previously outlined. It is evident that in the latter case there is no sudden concentration of energy when the electrode touches the work.

Results of a thorough, mathematical study of the problems involved are briefly summarized in the following paragraphs.

In the welding generator, two distinct problems exist:

1. The current must be held constant during rapid changes of conditions. This is solved by the use of reactance.

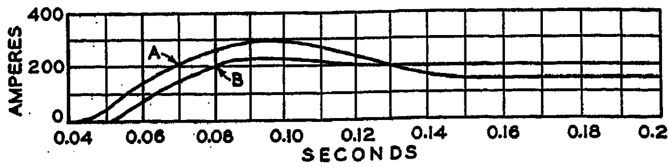


Fig. 3. Current-time relations in a neutralized welder suddenly subjected to full load. (A) Shunt and separately-excited fields independent; (B) single winding used for both

2. The machine must be so designed that the voltage generated may vary rapidly to meet changes of conditions without much change of current.

It is essential to recognize that there are two distinct problems and not one, and that only the second of these requires the use of a special generator. Every change in voltage involves a change in field strength, and in connection with this the following requirements should be noted:

1. Rapid changes require that field variations must take place with only a small inflow or outflow of magnetic energy to the field; or in other words, *the magnetic energy stored in the field shall be as small as possible.* For this purpose the generator should be designed with: (a) low saturation, (which will be secured in any case, owing to the need for a high voltage on open circuit); and (b) the shortest possible air-gap involving semi-closed rotor slots and laminated pole tips.

2. Low magnetic energy means very rapid increment or decrement of flux to meet changed conditions; and also the absence of oscillations where a large external self-inductance is used.

3. Oscillations are due primarily to the fact that the magnetic energy stored in the field is about equal to that in the reactance. This condition should be avoided; the energy stored in the reactance should be much greater than that stored in the field.

4. To store a large amount of energy, the reactance should have many turns, and a fairly long air-gap. (It may be made of cast iron, or cast steel.)

5. It is common practise to use for this purpose the reactance of the armature circuit due to the cross-flux. This is bad practise because: (a) The necessity for a short air-gap has just been pointed out in the interests of low stored field energy. (b) If there are many armature turns with a short air-gap, the cross-flux will produce high saturation, tending to increase the stored field energy: (c) If the pole arc is wide this cross-flux will create sparking. (d) If we reduce the pole arc to avoid this, we reduce the reactance formed by the cross-flux and increase the reluctance of the field. (e) A concentrated interpole winding diminishes the effectiveness of the machine as a reactance.

6. Because of this, it is better to use a *neutralizing winding* or distributed interpoles, completely abolishing the cross-flux, and to have the reactance in separate form. The endeavor to combine the conditions for maximum reactance and the opposite conditions for minimum field energy mean that neither set of conditions can be met satisfactorily; only separate pieces of apparatus can satisfy both in the best possible manner.

7. Even with a purely separately-excited machine this is true. If there is a shunt coil in addition, the placing of the reactance external to the tapping points of the shunt circuit has the further advantage of shielding the shunt winding from the rapid oscillations of the arc.

8. Owing to lag caused by the self-induction of the main field, connecting the shunt winding directly across the arc does not enable it to follow rapid variations, although it can follow fairly slow ones. It is therefore better to rely upon the reactance to deal with rapid variations, and shield the shunt winding from them.

9. The lower the field energy and the higher the field resistance, the more rapid are the variations which can be followed.

10. The higher field resistance also tends to check oscillations but more power is required for excitation, and in a machine with a shunt circuit it is desirable that the field resistance be such as will give the constant-current condition. It seems better therefore to rely on other means; namely, low field energy, and high external reactance to avoid oscillations, and *not* connecting the shunt circuit directly across the arc. This last is perhaps a point of secondary importance, and one to which some difference of opinion might be allowed.

11. Leakage self-induction in the shunt or separately-excited circuit prevents rapid response by permitting the shunt current to vary at a different rate from the armature current. Such leakage is the *sole* cause of these variations.

12. If there is no leakage between the series coil and the shunt or separately-excited coil, all currents must vary at exactly the same rate making "sluggishness" impossible.

Welders designed in this way may be built conveniently with slotted stators, although this is not necessary. This construction renders it possible to reduce greatly the cost of a welding set by combining the welding generator itself with an induction motor in the same magnetic structure. It can be accomplished as shown in Fig. 4. The two machines are arranged for different pole numbers, circuits belonging to the welding generator being at the back of the slots while those of the induction motor are at the front. The rotor has an ordinary d-c. winding suitable for the welding generator and fitted with equalizers. Through these equalizers the secondary currents of the induction motor flow, and in this way are prevented from appearing at the commutator at all. An illustration of the complete apparatus as built with vertical shaft is given in Fig. 5.

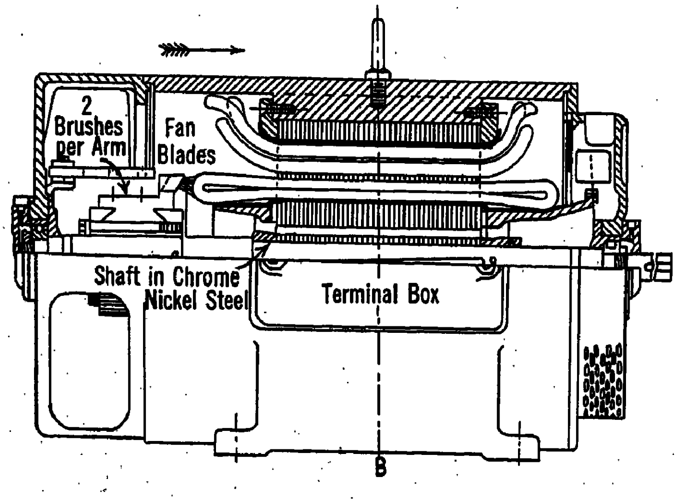


Fig. 4. Combined welding generator and induction motor with slotted stator

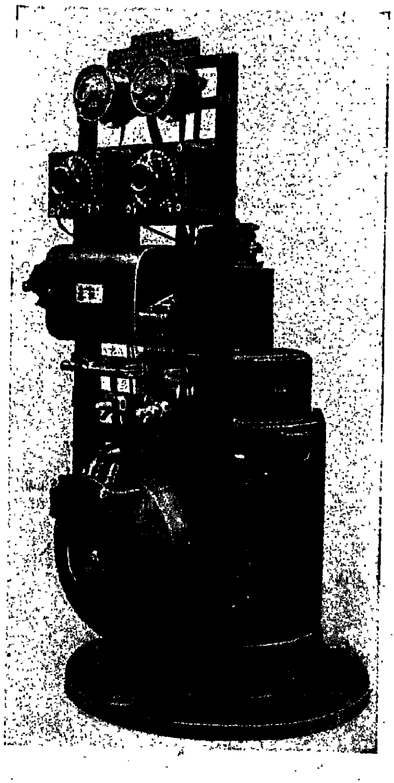


Fig. 5 Complete neutralized d-c. welding set built with vertical shaft

Some Effects of Unbalanced Faults

By
R. D. EVANS and S. H. WRIGHT
Member A. I. E. E. Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Line-to-ground voltage in three-phase grounded-neutral electric power systems under fault conditions often may be greater than the line-to-line voltage. This and numerous other important relations are shown by an investigation of the wide range of power-system voltages and currents existing under fault conditions.

SINCE THE INTRODUCTION of the method of symmetrical components as a powerful tool for the solution of electric-circuit problems, it has been used in many system analyses. Utilizing symmetrical components, this article shows by means of curves and tables the full range of fundamental-frequency voltages and currents obtained in a three-phase system under various fault conditions; it discusses also certain phases of application such as grounding and circuit-breaker duty, and points out the not generally appreciated existence of certain abnormal values in typical systems.

In terms of symmetrical components any symmetrical system is defined and described fully by the generator voltages and the positive-, negative-, and zero-sequence impedances. Thus, Fig. 1 shows the equivalent diagrams of a system for three-phase, line-to-line, single-line-to-ground, and double-line-to-ground short circuits. Since the system is symmetrical, identical values of voltage and current are obtained for any one type of short circuit regardless of which particular phases are faulted; details of the analytical work are simplified for any one type of short circuit, however, if the reference phase (phase *a*) is the one which is open when the other two phases are faulted, and vice versa. Fig. 2 shows the sequence network connections from which the components of current and voltage of phase *a* are computed; and from these latter, in turn, the components for phases *b* and *c* are obtained readily. Because of the large number of possible variables it is desirable before drawing up curves illustrating the ranges of voltages and currents to make certain common assumptions and simplifications. For instance, it is assumed that the system is short-circuited from no-load and internal generator voltages equal and in phase; that the system is without shunt capacitance; and that short-circuit currents are limited only by (inductive) reactance except in the ground-current path, where resistance also is considered. For the sake of generality the sequence impedances are expressed as ratios to the positive-sequence reactance, the latter being that which determines the three-phase short-circuit current; currents are expressed as ratios to the three-phase short-circuit current, a convenient reference quantity; voltages, both line-to-ground and line-to-line, are expressed as ratios to their respective *normal* values. Thus for a given system the curves may be used by computing the ratios of sequence impedances.

TABLE I—LIST OF SYMBOLS
(See Illustrations)

a, b, c = the three phases of a three-phase system in which normal phase sequence is a, b, c.
E_a, E_b, E_c = line-to-ground voltages at point of fault.
E_{ab}, E_{bc}, E_{ca} = line-to-line voltages at point of fault.
E_G = generated positive-sequence voltage of phase a, at the source; when several machines are involved, this becomes an equivalent generated voltage. (*Studies of Transmission Stability*, by R. D. Evans and C. F. Wagner, A. I. E. E. TRANS., 1926, Vol. XLV, pp. 73 and 79.)
E_1 = positive-sequence voltage at point of fault.
I_a, I_b, I_c = line currents at point of fault.
I_g = ground current at point of fault. ($= 3\ I_0$)
I_0 = zero-sequence current at point of fault.
R = fault resistance.
R_g = fault resistance affecting directly the flow of ground current of a double-line-to-ground fault.
R_L = fault resistance in each of the faulted phases of a double-line-to-ground fault.
R_0 = zero-sequence resistance (per phase).
R_1 = positive-sequence resistance (per phase).
R_2 = negative-sequence resistance (per phase).
X_0 = zero-sequence reactance (per phase).
X_1 = positive-sequence reactance (per phase).
X_2 = negative-sequence reactance (per phase).
Z_0 = zero-sequence impedance (per phase).
Z_1 = positive-sequence impedance (per phase).
Z_2 = negative-sequence impedance (per phase).

NOTE: All currents, voltages, and impedances listed above are scalar quantities; an inverted circumflex ($\check{E}_g$) above any symbol indicates the vector form, which may be expressed in terms of complex numbers.

The titles and legends make the curves practically self-explanatory. (A list of symbols is given in Table I.) Voltages and currents at the fault location are shown in Figs. 3 to 7 inclusive. In Fig. 3 all resistances are taken equal to zero, voltages and currents being plotted as functions of the sequence reactances. Since in a resistance-grounded system the zero-sequence resistance is an important factor in Figs. 5 and 6 this is taken as a variable. In these two illustrations only the curves for the case of positive- and negative-sequence reactances being equal ($X_1 = X_2$) are given here. Positive- and negative-sequence reactances are equal for symmetrical static networks, but rotating

---

From "Power System Voltages and Currents Under Fault Conditions," (No. 31-59) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931.

machines in a system may cause these reactances to differ. Table II summarizes the ranges of voltages and currents shown in these figures.

TABLE II—RANGE OF FAULT CURRENTS AND VOLTAGES

Type of fault	Current ratio* Line	Current ratio* Ground	Voltage ratio *L-G*†	Voltage ratio *L-L*‡
L-L	0.69—1.15		0.67—1.20	0.58—1.04
L-G	0.00—2.00	0.00—2.00	0.58—1.97	0.67—1.20
2*L-G*	0.69—2.02	0.00—3.00	0.00—1.80**	0.00—1.04**

Based on $\frac{R_1}{X_1} = \frac{R_2}{X_1} = 0 \qquad 0 \leq \frac{R_0}{X_1} \leq \infty$

and $\frac{X_2}{X_1} = 0.5 \text{ to } 1.5 \qquad 0 \leq \frac{X_0}{X_1} \leq \infty$

*Reference is the three-phase short-circuit current.

†Reference is the normal line-to-neutral voltage.

‡Reference is the normal line-to-line voltage.

**These voltages are identical; only the line-to-ground voltage curves have been plotted.

One of the most important facts brought out by these curves is that the line-to-ground voltage may rise to a value of 190 per cent of normal (somewhat greater than the normal *line-to-line* voltage), a fact not generally appreciated. It is interesting to note that the ratios of line and ground current to the three-phase short-circuit current may be as great as 1.5 and 3.0, respectively; also, that the ground current of a double-line-to-ground fault may be much greater than the maximum value of a single-line-to-ground fault. Some of these values are still greater for cases (not shown here) where the negative-sequence reactance is not equal to the positive-sequence reactance.

It is pertinent to say (as the curves show in part), that generally the maximum values of fault currents are obtained with low values of zero- and negative-sequence *reactances*; and correspondingly, that the maximum values of voltages occur with high values of zero- and negative-sequence *reactances*; for zero-sequence *resistance* (R_0), however, such is not the case; maximum values of currents and voltages are obtained mostly with intermediate values of R_0. Also it may be noted that the adding of zero-sequence resistance to a system having no resistance increases the line current on a double-line-to-ground fault; consequent increase of this resistance reduces line currents as well as ground currents, but increases line-to-ground voltages.

SYSTEM PERFORMANCE

From the foregoing it is evident that two systems of the same voltage having identical values of three-phase short-circuit current for particular fault locations may have radically different voltages and currents for *unbalanced* faults. Line currents are important because of the mechanical stresses which they set up in rotating machines, transformers, reactors, circuit breakers, and bus structures. High voltages are important because of the stresses produced by them on apparatus or line insulation, as well as on lightning arresters. In circuit-breaker and relay applications combinations of voltage and current are important. Certain applications require consideration not only of the symmetrical effective values of voltages and currents as given but of asymmetrical components, machine harmonics, and high-frequency oscillations resulting from stored energy changes. Some aspects of certain general system problems will be discussed briefly:

The general classification of systems with respect to grounding is (1) ungrounded, (2) grounded through

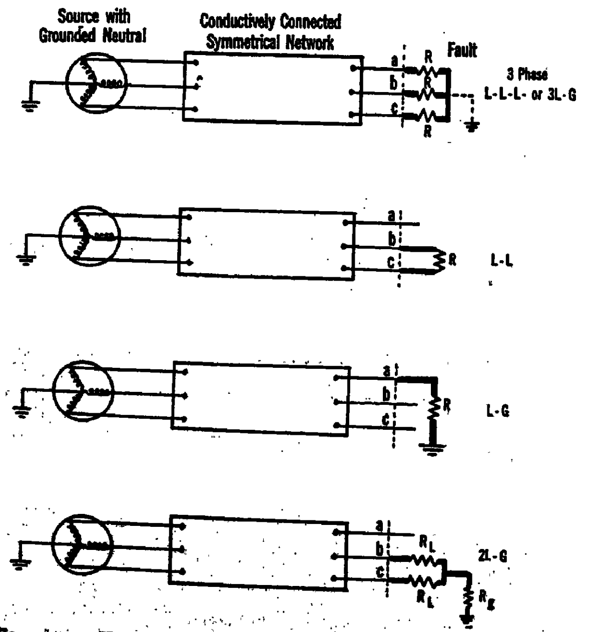
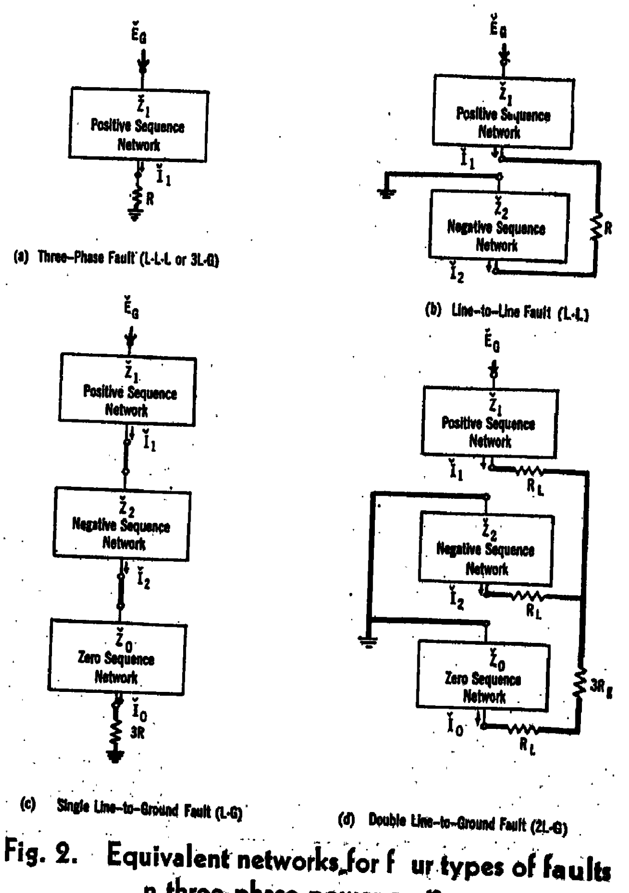

Source with Grounded Neutral
Conductively Connected Symmetrical Network
a
b
c
R
Fault
3 Phase L-L-L- or 3L-G
L-L
L-G
R_L
2L-G
R_g

Fig. 1. Types of faults in three-phase systems



(a) Three-Phase Fault (L-L-L or 3L-G)

(b) Line-to-Line Fault (L-L)

(c) Single Line-to-Ground Fault (L-G)

(d) Double Line-to-Ground Fault (2L-G)

Fig. 2. Equivalent networks for four types of faults in three-phase power systems

impedance (resistor or reactor), and (3) free neutral.

(For the purpose of this classification, a system grounded through neutral reactance resonating with line capacitance may be viewed as a free-neutral system, since the object of the reactance is to nullify line capacitance; in this paper the phenomena of arcing grounds is not treated, and in general the grounding impedances are assumed to be so low that arcing grounds are avoided.)

It is a fact, however, that actually the zero-sequence impedance of a direct-grounded system may be higher than that of a system of similar capacity and extent which is grounded through a neutral impedance of low value. Obviously, the classification given is unsatisfactory since it takes into account only the impedance between ground and neutral points of certain pieces of apparatus, instead of the total effective zero-sequence impedance which includes line and apparatus impedance as well as that of grounding resistors and reactors.

A much more accurate classification of systems with respect to grounding is suggested by Figs. 3 to 6. The curves as given cover the full range of system grounding from a direct-grounded system to a free-neutral system, and suggest that *the ratio of zero-sequence impedance to positive-sequence reactance be used as a criterion or measure of the "degree of grounding,"* low values of this ratio corresponding to a solidly-grounded system and high values to a free-neutral system. Hence, the criterion is not one by which to determine whether there is an impedance between one or more neutral points and ground but, more accurately, whether the ratio of zero-sequence reactance or resistance to positive-sequence reactance is high or low. For convenience this ratio is called the "zero sequence impedance ratio."

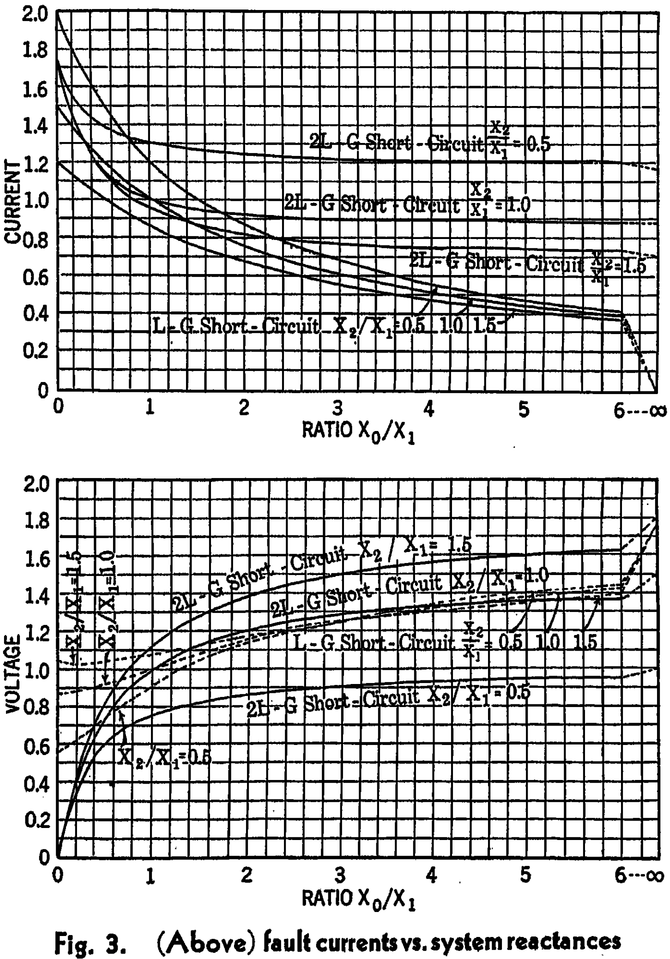


Fig. 3. (Above) fault currents vs. system reactances and (below) fault voltages vs. system reactances for single- and double-line-to-ground faults

Currents (above) are expressed as a ratio to the three-phase short-circuit current. Voltages (below) are line-to-ground values and are expressed as ratios to the normal line-to-neutral voltages. $R_1 = R_2 = R_0 = 0$ in all cases

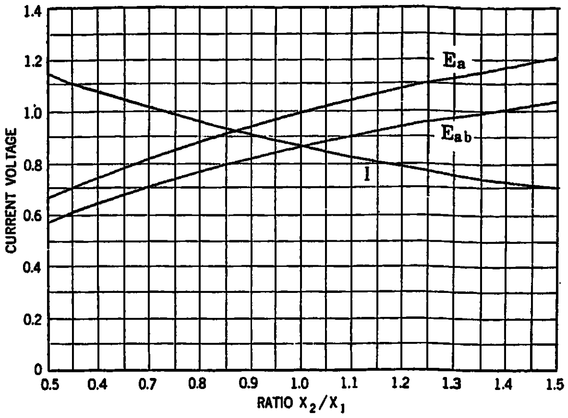


Fig. 4. Fault current and voltages vs. system reactance for line-to-line fault

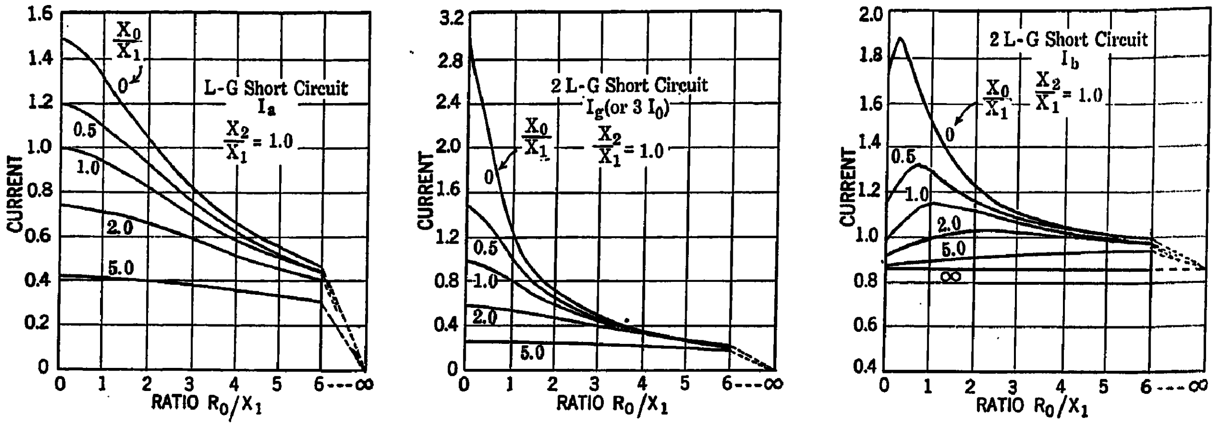
Current is expressed as a ratio to the three-phase short-circuit current; voltages are expressed as ratios to their respective normal values

Various methods of grounding a system have rather complicated effects on stability limits. Decrease in positive-sequence voltage may cause an underexcited and overloaded synchronous machine to pull out of step without causing the system as a whole to lose synchronism. At various times it has been suggested that the positive-sequence voltage at the fault location is a measure of the stability of a system under fault conditions. Accordingly, Fig. 7 has been plotted to show the range of this voltage for single- and double-line-to-ground faults respectively. Voltage is plotted as a ratio to the normal line-to-neutral voltage, and impedances are expressed as ratios to the positive-sequence reactance.

CIRCUIT-BREAKER OPERATION

The effective current flowing through a pole of the breaker before it opens, and the effective voltage occurring across that pole after opening are used often as a measure of the duty imposed in opening a short circuit. It should be clearly realized that this measure does not take all factors into account. Dr. Joseph Slepian has pointed out that the most significant factor is the rate of restoration of voltage at the instant at which the current passes through zero.

The phenomenon of arc extinction has been likened to a race between the build-up of voltage, and the deionization of particles in what was the arc stream before the arc was extinguished. Recovery voltages are affected by the presence of asymmetrical currents,



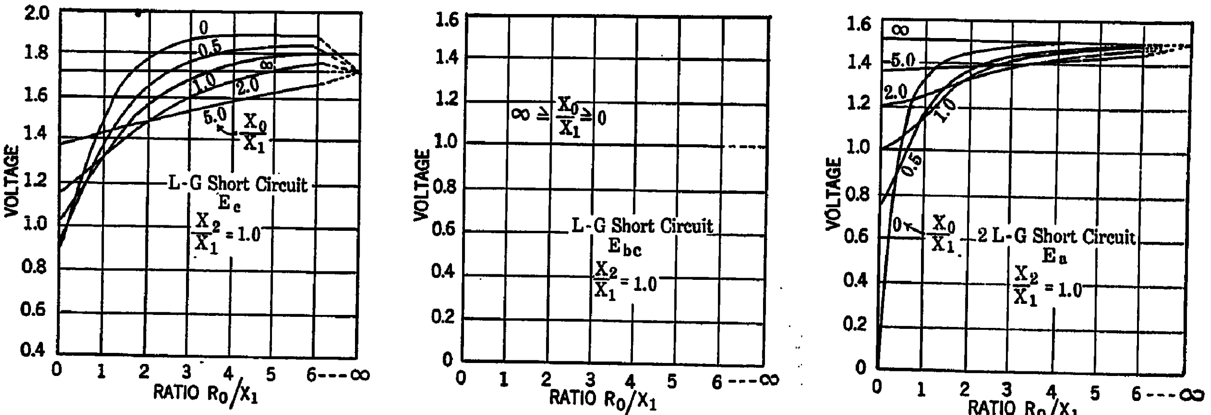
Line current for single-line-to-ground fault

Ground current for double-line-to-ground fault

Line current for double-line-to-ground fault

Fig. 5. Fault currents vs. system impedances for different types of faults

Curves in each group are for various values of the ratio X_0/X_1. All currents are expressed as a ratio to the three-phase short-circuit current



Line-to-ground voltage for single-line-to-ground fault

Line-to-line voltage for single-line-to-ground fault

Line-to-ground voltage for double-line-to-ground fault

Fig. 6. Fault voltages vs. system impedances for different types of faults

Curves in each group are for various values of the ratio X_0/X_1. All voltages are expressed as ratios to their respective normal values

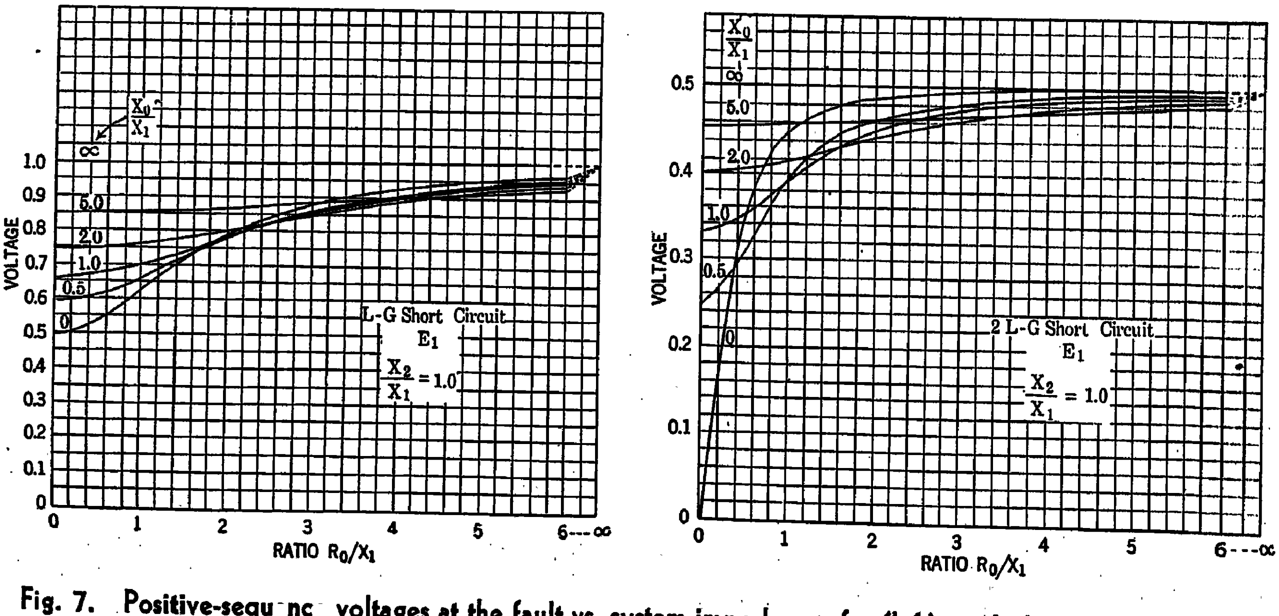


Fig. 7. Positive-sequence voltages at the fault vs. system impedances for (left) single-line-to-ground and (right) double-line-to-ground faults

Curves in each group are for various values of the ratio X_0/X_1. All voltages are expressed as ratios to the normal line-to-neutral voltage machine harmonics, and high-frequency oscillations, but any of these may either increase or decrease the rate of restoration of voltage; hence, it probably is true in comparing two similar systems of the same voltage and equal three-phase short-circuit current that the system with the highest effective recovery voltage for fault conditions will have the highest rate of change of voltage at the critical point of the wave. Regardless of whether the product of the effective current before the pole opening and the effective voltage after the pole opening may be taken as a measure of breaker duty, this product appears to be suitable as a measure of the influence of the sequence impedances on circuit breaker duty.

For the various steps possible in the clearing of the different types of faults the aforementioned product has been computed and plotted in Fig. 8. This product is obtained from the curves of Fig. 3. For example, with a three-phase grounded short circuit, the opening of the first pole changes the fault from a three-phase to a double-line-to-ground fault and the product is of the three-phase short-circuit current and the voltage of the double-line-to-ground fault. The ordinate of Fig. 8 is the ratio of the product of voltage and current for a particular pole to the corresponding product of the three-phase short-circuit current and the normal line-to-neutral voltage; the abscissa is the ratio of zero-sequence to positive-sequence reactance. For the sake of simplicity all resistances have been assumed as zero and curves are shown only for the case of positive- and negative-sequence reactances being equal.

The curves of Fig. 8 indicate that under some conditions any tendency for one pole to open before the others becomes augmented as a result of the increased duty imposed on the last poles to open (regardless of the fact that the breaker may be in proper adjustment). This may be compared to a state of unstable equilibrium. The following points are salient: (1) when zero-, positive-, and negative-sequence reactances are equal the circuit breaker kva. per pole is independent of the type of fault or the sequence of opening; (2) for any other ratio of zero-sequence to positive-sequence reactance the maximum kva. per pole is increased for some one step in the sequential opening of a breaker on a three-phase fault. Thus there may be a wide range of values of the kva. per pole when clearing faults, depending upon the type of fault, sequence of pole opening, and the sequence impedance ratios.

Comparison of Grounding Methods

The previous analysis shows definitely that the fault voltages or currents may be taken as factors indicative

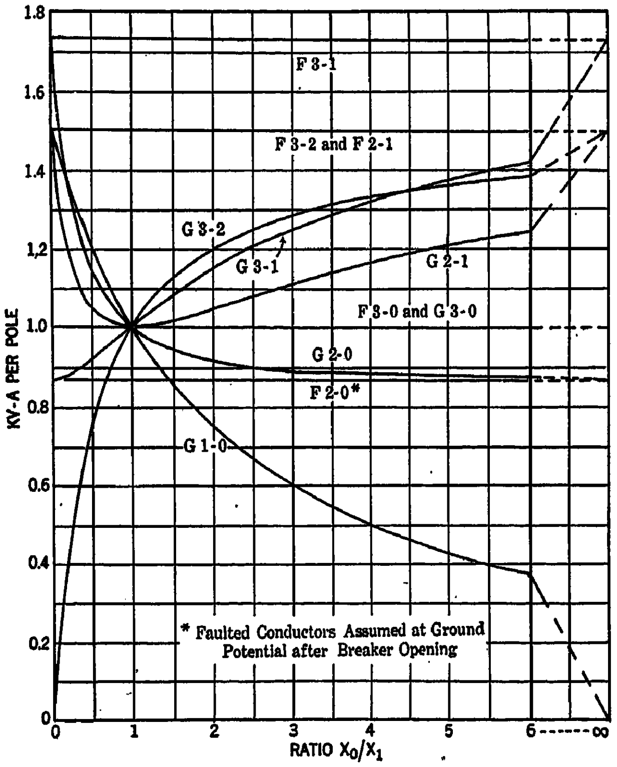


Fig. 8. Circuit-breaker kva. vs. sequence reactances for $X_1 = X_2$

Each curve shows the kva. for a pole the opening of which is one particular step in clearing a fault; curve labeling indicates number of poles closed both before and after this opening, and whether fault is grounded or free from ground (*G* or *F*). Ordinates are ratios of the product of the symmetrical r. m. s. current through a pole before opening and the voltage after opening, to the product of the three-phase short-circuit current and the normal line-to-neutral voltage. All resistances are taken equal to zero

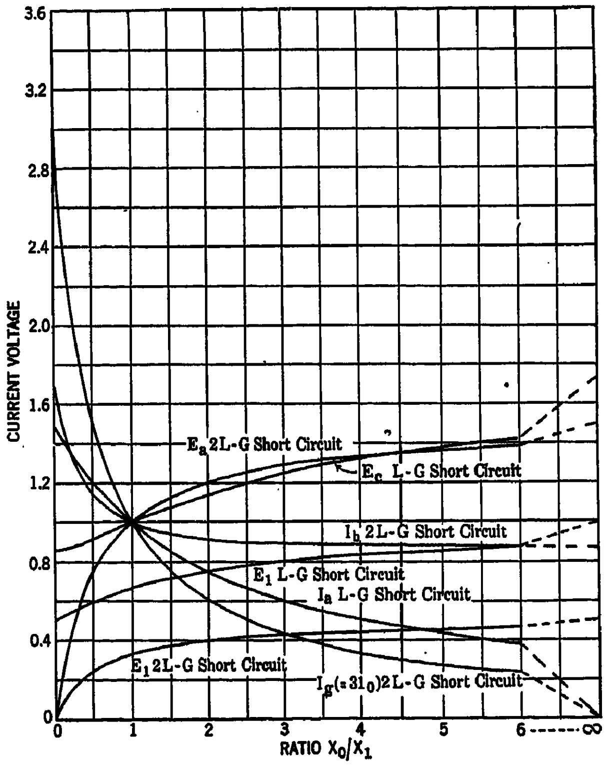


Fig. 9. Typical curves for system grounding study. Fault currents and voltages vs. zero-sequence reactance ratio for system in which $X_1 = X_2$ and all resistances are negligible

Ordinates are fault currents and voltages; currents are expressed as ratios to the three-phase short-circuit current; voltages as ratios to the normal line-to-neutral voltage. These curves were derived directly from Figs. 3, 4, 5, 6, and 7 of certain aspects of system performance, and that they are determined mainly by the value of the zero-sequence impedance ratio. Obviously a preferred value of this ratio depends upon the weight given to the various factors and upon the particular system involved. Fig. 9 illustrates the use and value of the foregoing analysis as applied in a study of system grounding. It is important to note that (1) as the ratio of zero-sequence to positive-sequence reactance varies from 0 to 1, the disadvantages decrease and the advantages increase while, (2) as this ratio goes above 4 there is relatively little of either gain or loss. Hence, the *preferred range of the zero sequence impedance ratio appears to be from 1 to 4.*

Fundamental Basis for Distance Relaying

For single-line protection, with the exception of pilot-wire, or superposed high-frequency methods, distance relays form the nearest approach to the theoretically ideal system. Except for errors due to fault resistance, these relays operate accurately according to the relative distance to faults.

By
W. A. LEWIS Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Associate A. I. E. E.

L. S. TIPPET (Formerly) West. Elec. & Mfg. Co., East Pittsburgh, Pa.
Non-member

AN IDEAL SYSTEM of relays for the protection of a sectionalized transmission line is one capable of dividing into two classes all faults on the lines it protects; in one, those faults occurring between the relay and the next sectionalizing point; and in the other, all other faults. It should also be capable of making this classification instantaneously. If a fault falls into the first class, the circuit breaker may be tripped immediately, thus reducing damage at point of fault and shock to the system; in general, permitting operation nearer the stability limit. If the fault falls in the second class, the circuit breaker would not be tripped or tripped only after a time delay which is great in comparison with the time required for breaker operation.

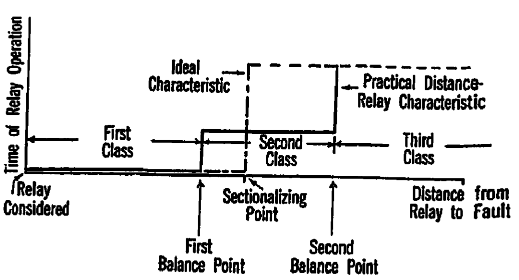


Fig. 1. Ideal and practical characteristics for distance-relaying systems

Exclusive of pilot wire or superposed high-frequency methods, the closest approach to this ideal for single line protection is attained by the use of distance relays. For parallel-line protection a somewhat closer approach to the ideal has been obtained by balanced-current relays; but additional protection is required for single-line operation and to care for the possibility of simultaneous faults on both lines, for this distance relays are well suited. Hence, if the distance relays can be made sufficiently accurate and rapid, the use of the balanced-current relays is non-essential.

Since distance relays cannot indicate with 100 per cent accuracy the distance to the fault, an additional intermediate class of faults must be introduced (see Fig. 1) comprising those which occur near the end of the section on both sides of the sectionalizing point. If a fault falls into the intermediate class, there is introduced a time delay sufficient to allow a breaker at the next sectionalizing point to trip in response to its relays which operate instantaneously; if the fault is just beyond the next sectionalizing point, it will fall into the first class of faults for the relays located at that point, and the fault will be cleared by the opening of the breaker at that point, allowing the first relay to reset; if the fault is just within the section, the relay at the original station will operate at the expiration of the time delay. Thus the final classification of faults falling in the intermediate class is made with the assistance of other breakers and relays.

In order to strike the boundaries of the intermediate class, it is convenient to call the points at which faults must occur "balance points," since the relays must just balance between one type of operation and another for faults at these points.

Distance relays may be of either the impedance or reactance type, operating on the indicated impedance or reactance of the circuit from the relay to the fault, obtained by comparing the voltage and current at the relay location. These indicated impedances and reactances are approximately proportional to the distance from the relay to the fault. They do vary somewhat,

---

From "Fundamental Basis for Distance Relaying on Three-Phase Systems," (No. 31-61) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

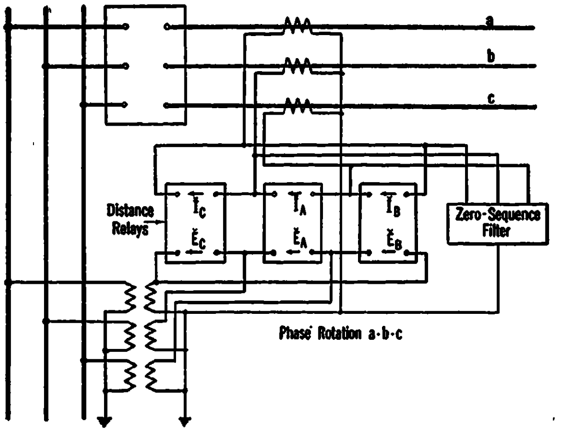


Fig. 2. Improved distance-relay connections for line-fault protection using delta-connected relays and zero-sequence filter

however, causing the locations of the balance points to shift accordingly. The greater the variation in balance point location, the larger the intermediate class must be made, and the greater are the departures from the ideal protection. If the variations in balance-point location are too great, this type of protection cannot be applied. It is, therefore, important to determine the causes of this shift in balance point and to develop methods of reducing or eliminating it.

For protection against line faults involving two or more line conductors, conventional relay connections make use of the line-to-line voltage and the line current which lags the voltage by 30 deg. at unity power factor. Analysis shows that both the indicated impedance and reactance are subject to variations for a fault in a given location dependent upon the fault resistance, current feeding the fault from the opposite end of the section, current in the remaining conductor, and current in the earth or other grounded paths. Variations in the balance points are, therefore, due to the same causes. Further analysis reveals that if "delta currents" obtained either by connecting the current transformers in delta or the current windings of the relay in delta with a suitable zero-sequence filter are used for relaying, (see Fig. 2) the two latter causes of variation are eliminated.

For protection against faults involving ground, conventional relay connections make use of line-to-ground voltage and line current. An analysis of this type of fault shows that the indicated impedance and reactance are subject to variations due to the fault resistance, the current feeding the fault from the opposite end of the section, the current in the other conductors, the mutual impedance between two parallel lines, and the difference between the impedance to balanced three-phase currents, or positive-sequence impedance and the impedance to balanced ground current or zero-sequence impedance. Further analysis shows that all of these effects except the first two may be substantially compensated, so that variations are produced only by fault resistance and the fault current feeding the fault from the opposite end of the section. This compensation may involve modifying either the current or the voltage in proper proportions. (See Figs. 3 and 4)

Thus, by the use of suitable methods, either the impedance or reactance type of distance relay for either line or ground faults may be made to measure accurately

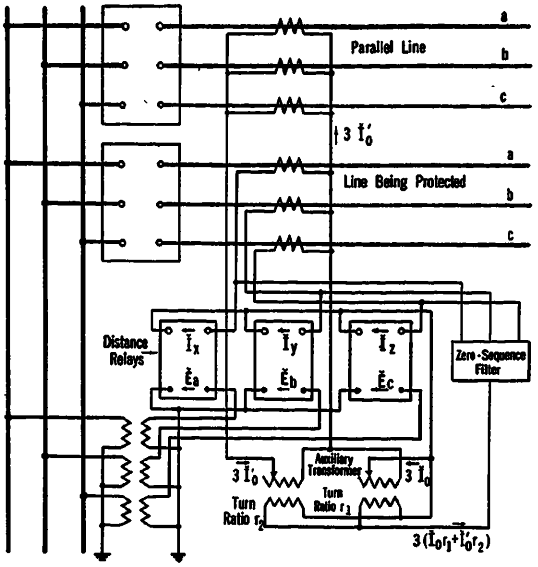


Fig. 3. Improved distance-relay connections for single-line-to-ground faults using current compensation

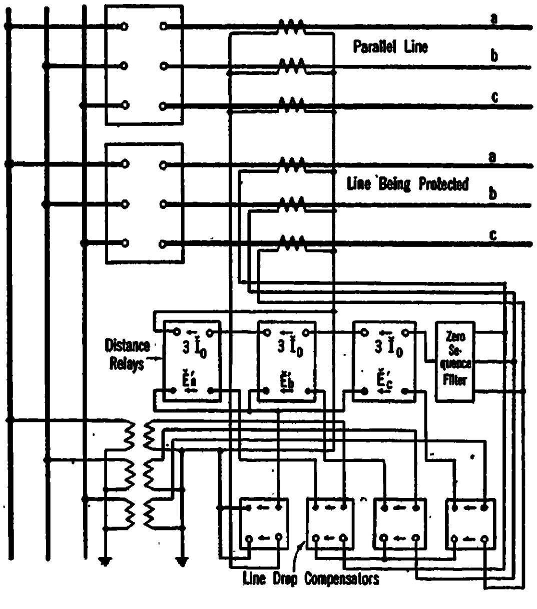


Fig. 4. Improved distance-relay connections for single-line-to-ground faults using voltage compensation

the distance to the fault except for the effects of fault resistance, the current from the opposite end of the section affecting the relays only when fault resistance is present. The effect of fault resistance may be represented by adding vectorially to the proper line impedance a resistance equal to the fault resistance, and a second term equal to the fault resistance multiplied by the vector ratio of two currents, these latter being functions of the currents feeding the fault from the two ends of the section, or their symmetrical components. Since the line impedance is generally principally reactive, the two resistance terms will add approximately at right angles, thus causing only moderate increases in the magnitude of the sum, unless the resistance terms are very large. The impedance relay operates on the magnitude of the sum of the three terms. This increases slightly with increasing fault resistance, and causes the balance points to shift toward the relay. On the other hand the reactance relay operates on the reactive component of this vector sum, and is therefore unaffected by the first fault-resistance term. If the two currents involved in the ratio are not in phase, the second fault-resistance term will have an apparent reactance which may be positive or negative depending upon which current is leading, so that the balance point may be shifted in either direction. Although generally the shift will be smaller than that produced by the same resistance using an impedance relay, the fact that it may be in either direction must be taken into account. Where fault resistances are moderate, as on most line faults if cleared rapidly, the total variation in balance point will often be quite comparable for the two types of relays. On ground faults the fault resistances are generally higher, so that some form of relay which is substantially independent of resistance is generally required, and accuracy thus reduced.

It should be pointed out that the design of the relay, its simplicity, reliability, and speed of operation, as well as possible accuracy, must be considered in choosing the type of distance relay to be used for a given protection.

From this analysis the following conclusions may be drawn:

1. Conventional methods of distance relaying are subject to errors other than those caused by fault impedance.

2. These errors may be eliminated in relays protecting against line faults by the use of "delta relaying," obtained either by connecting the current transformers in delta or by connecting the current windings of the relays in delta, using a suitable zero-sequence filter.

3. These errors may be eliminated in relays protecting against ground faults by the use of current or voltage compensation, and therefore if the impedance of the section being protected is sufficiently great distance relaying is suitable for ground fault protection.

4. Errors introduced by fault impedance, comprise the chief limitation in the application of distance relaying, but these decrease with increasing section impedance. This limitation affects distance relays of both the impedance and reactance types, although to different extents.

5. Distance relaying may be made to approach even more closely the desired relaying ideal, and within the limits of its application it should give satisfactory protection regardless of generator capacity or system conditions.

Shallenberger Personal Memoranda Discovered

A MEMORANDUM of Oliver B. Shallenberger, personally handwritten, and recently come to light, gives an interesting glimpse of the electrical business forty years ago. The man who left this penciled notation was one of the pioneer electrical engineers of the then infant Westinghouse company and was active in many major projects that did much to shape the course of the industry.

A young man when he first entered the electrical industry from the Navy after a course at Annapolis where he specialized in physics and electricity, he was still a young man when he died at the age of thirty-eight after fourteen years of creative effort.

His invention of the meter was in 1888 under very unusual circumstances and at a time when at least one justifiable criticism of alternating current was that there was no meter for measuring it and no motor to be used with it. In assembling a new form of arc lamp for test, a small spring dropped down between an actuating coil and an iron core; Shallenberger, standing near, noticed that the spring began to turn slowly and he restrained the attendant from picking it up with, "Let's see what makes the spring revolve." He saw and exclaimed, "There's a meter in that—and perhaps a motor!"

Shallenberger was at that time 28 years old. In 1889 he was sent abroad by his company to study European central stations. In 1891 he resigned because of ill health and spent several winters in Colorado, a victim of tuberculosis.

While in the West he conceived the idea of transmitting power from Canon City to the famous mining camp at Cripple Creek. In 1890 he had helped to promote the Telluride project of carrying power three miles—a revelation at that time; in 1897 he formed the Colorado Power Company of which he was president until his death.

Part of the time after his resignation was spent working in his own laboratory in Rochester, Pennsylvania, and it was there that he studied the Cripple Creek transmission and made the notations that have been discovered.

On one side of the memorandum are listed machines and equipment with prices, weights, and freight costs which form an interesting comparison with modern apparatus. Three 470-kw. dynamos are priced at $9,000 each and weighed 37 tons. Present-day machines of corresponding rating would cost about $6,500 and weigh 17.5 tons. A lightning arrester of the type he priced at $178 would cost now only about $75.

On the reverse side of the same memorandum are notations pertaining to rates and data on an expected electric lighting load, "current 28c. kw-hr., arc lamp at $15 a month," etc.—*Contributed.*

Power Supply for Telephone Service

Automatic regulating and control equipment is finding increasing use in telephone power plants, giving more exact performance, increased reliability and reduced maintenance. Certain regulating equipment and a few of the unit-type automatic power plants recently developed are described.

By
R. L. YOUNG
Member A. I. E. E.
American Tel. & Tel. Co., New York

R. L. LUNSFORD
Member A. I. E. E.
Bell Tel. Laboratories, Inc., New York

CONTINUITY and reliability of service have been keynotes guiding development of telephone power plants for many years. Duplicate equipment, reserve storage batteries, and emergency sources of power supply are regularly provided as required. A review of data available in some metropolitan districts indicates that a high percentage of continuous performance has been obtained during the past twenty years, exceeding 99.999 per cent of full time.

Provision for quick change from regular to reserve units is required, of course, while voltage regulation of the d-c. supply and frequency regulation of signaling machines are necessary for proper performance of the telephone equipment. These requirements point to the use of automatic regulating equipment and automatic power-plant operating arrangements to as large an extent as practicable, particularly since continuous service must be maintained both day and night.

Installations of automatically-controlled power equipment in small telephone offices at several towns in Pennsylvania were made during 1917 to make continuous attendance by plant employees unnecessary, particularly over week-ends. Signaling hydrometers in the two main storage batteries controlled an automatically started mercury arc rectifier to recharge the batteries as necessary. Alarms were provided to indicate any failure of equipment or abnormal discharge.

Modern automatic power plants in small offices follow somewhat similar lines except that rectifiers of the hot-cathode tube type or the dry copper-oxide disk type are employed, and control of charging is by means of an improved type of ampere-hour meter. Control of output voltage is frequently by relays which introduce counter cells. For larger offices is employed motor-generator equipment controlled by an ampere-hour meter, or where continuous floating at a fixed voltage is used, by various other means to bring in additional generators when the load requires them, most of the latter being still upon a trial installation basis.

The considerable variations in load current which must be furnished by the power plant are illustrated in Fig. 1, which pictures the daily load cycles in offices of several classes. Although the power required to carry a voice current over a telephone line is surprizingly small, it is not realized sometimes that the equipment necessary to accomplish this and to operate mechanical switching devices, signaling lamps, and other equipment in large offices with much traffic is considerable.

In Group *D*, (Fig. 1) for example, two-thirds of a million calls were handled during the day by three metropolitan office units operated from one power plant. Group *E* with a peak of 5,300 amperes at 24 volts represents the load of long distance switchboards and repeaters distributed over ten floors, this load being supplied by motor-generator sets having combined capacity of 10,200 amperes while the storage battery has a rating of 34,880 ampere-hours and weighs 111 tons. Some 500 hp. is required to drive these generators, while an additional 300 hp. is provided for 130-volt telegraph and repeater plate generators not shown on this group. An additional 215 hp. is provided for a vacuum-tube system to handle message slips. Part of the installed horsepower is on reserve equipment. Two other telephone power plants are in the same building. It might be mentioned that primary power is purchased from the public service companies and nearly all of it is then converted into other forms suitable for telephone use.

A brief statement of the means employed for regulating the voltage of the main d-c. power supply may be of interest, since this has assumed considerable importance from the standpoint of proper circuit operation, especially in dial offices where the automatic-switching equipment requires regulated power, and in repeater offices where the vacuum-tube amplifiers must have regulation to insure uniform transmission gain and long life of tubes.

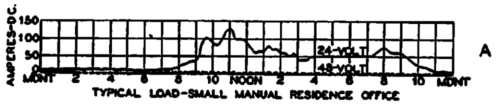
Many years ago a single-battery group was employed, and when the output voltage was regulated, counter-e. m. f. cells were cut in during battery charging and at other times when necessary. With the adoption of duplicate batteries and the continuous floating system under which all the current is supplied to the load from the generators while batteries are held in standby service, an improvement in voltage regulation was obtained, the normal daily variation of a 24-volt battery being reduced from about seven volts to two volts. To reduce the two-volt range obtainable with hand adjustment of the generators, an automatic voltage regu-

---

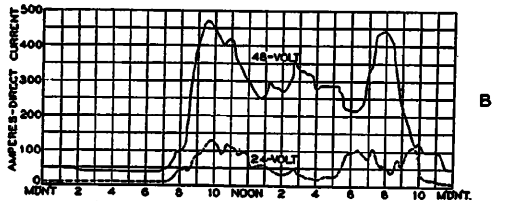
From "Automatic Power Plants for Telephone Offices," (No. 31-65) presented at the A. I. E. E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

lator having several novel features was developed. One of these regulators with case open is shown in Fig. 2.

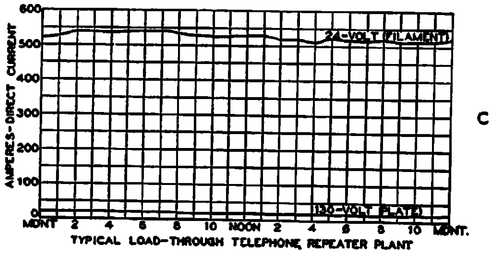
Commercial regulators available were not found satisfactory in this service since considerable "hunting" resulted from the slow response of voltage in a floated storage battery to changes of current flowing into it. This regulator includes a solenoid-operated voltage element contacting at intervals with a cam disk driven by a synchronous clock motor. The contacts are made for short periods at intervals of ten seconds, the duration of contact varying with the amount that the main-battery voltage is deviating from normal. A reversible motor drives a rheostat which varies the field excitation of the charging generator. This regulator is usually adjusted to maintain the voltage on the service bus-bars within about ± 0.15 volt. Simpler types of regulators are used on smaller installations.



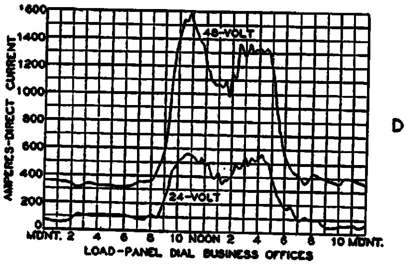
TYPICAL LOAD-SMALL MANUAL RESIDENCE OFFICE



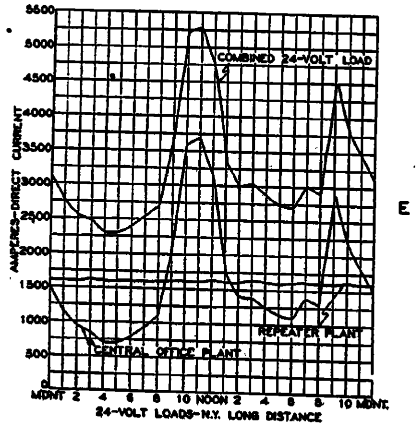
TYPICAL LOAD-PANEL DIAL RESIDENCE OFFICE



TYPICAL LOAD-THROUGH TELEPHONE REPEATER PLANT



LOAD-PANEL DIAL BUSINESS OFFICES



24-VOLT LOADS-N.Y. LONG DISTANCE

Fig. 1. Typical daily load variations in business, long distance, and residence telephone offices, morning and afternoon business peaks may be noted as well as the evening residential peak and the pick-up in long distance business as stimulated by reduced evening rates

Typical Unit-Type Automatic Power Plants

In the development of these plants the smaller and less complicated plants were naturally attempted first; those for small private branch exchanges of the dial type, which were required in considerable number, received early attention. The dial exchange has no operators and everything must be done mechanically or, more properly, electrically, obviously requiring a more complex power plant than that of the manual P. B. X. or even of the small manual central office. In addition to a source of direct current which will continue reliable during short periods of power failure and which will be regulated as to voltage, it is necessary to provide alternating current for ringing telephone bells; also a variety of tones and signals for information and supervisory purposes. A plant which is typical of several types developed for this general class of work is shown in Fig. 3. The plant is assembled as a unit with batteries in the lower cabinet and control equipment including fuses, meters, switches, relays, ringing ma-

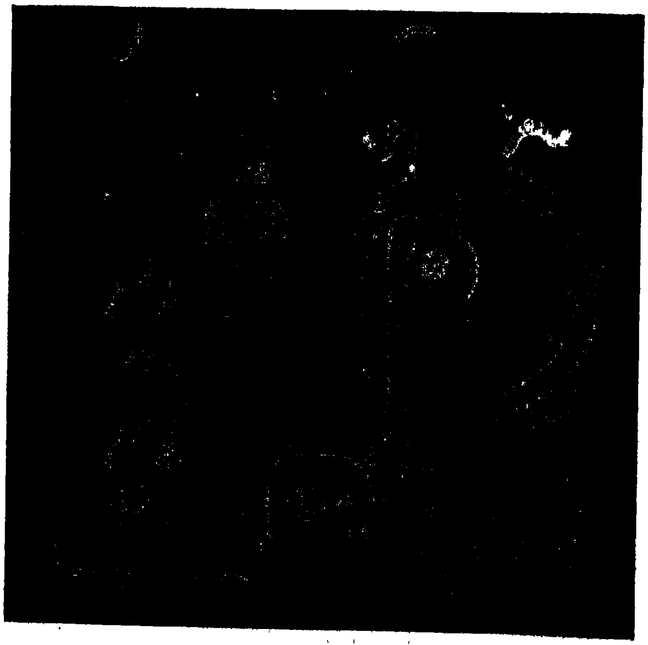


Fig. 2. Cam-type automatic voltage regulator for large machines and batteries

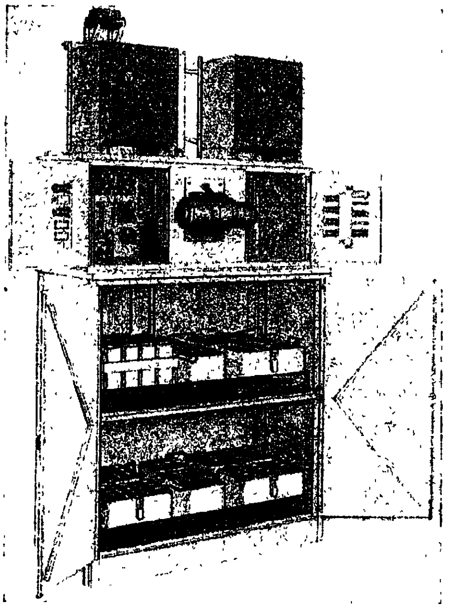


Fig. 3. Automatic power plant for dial private branch exchange; capacity 44-50 volts, 2.5-5 amperes

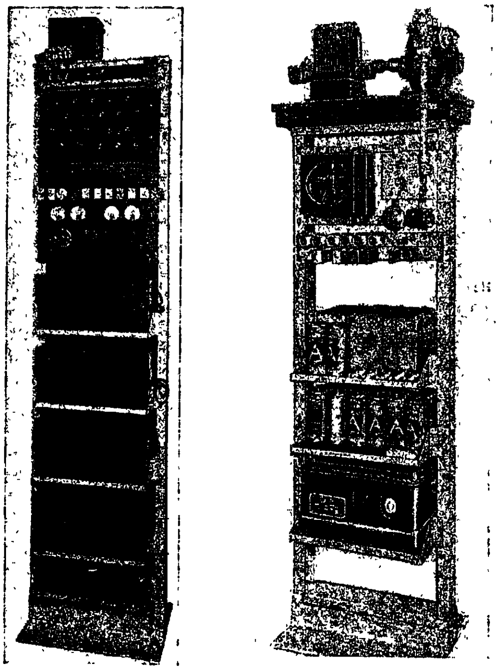


Fig. 4. (Left) Typical small plant for supplying vacuum-tube plate circuits; 125-135 volts, 50-200 milliamperes. (Right) Small plant for ringing and transmitter supply; 75-100 volts, 20 cycles and 8.5 volts direct current, 20 or 40 ampere-hours

chine, and automatic voltage control in an upper cabinet; the charging rectifiers are mounted above. In small plants the single rectifier is mounted within the cabinet. Storage batteries are of a type assembled in groups of three cells in a glass case and are equipped with indicators to show the approximate condition of charge.

Counter e. m. f. cells used for voltage control in the small plants having but a single battery are of a new type using nickel electrodes and alkaline solution. Neither plates nor solution are affected chemically during operation, so that the maintenance consists largely in adding water to replace electrolysis loss. The small panel-mounted ringing machine is of the inverted rotary-converter type with motor element operating upon the battery and the a-c. output fed to a step-up transformer arranged to give the proper operating voltages at about twenty cycles. This machine has automatic control, starting when a receiver is lifted from the switch hook and stopping after completion of the call. It is equipped with jack-and-plug connections for ready replacement by a spare machine when maintenance is required.

In this plant the charging equipment is arranged for continuous operation at an output which will carry a large percentage of the busy-hour load and will return to the battery during the light-load periods whatever discharge has been taken plus additional current to offset battery loss. A sensitive voltmeter-type relay actuating a solenoid-type switch automatically cuts in or out the counter cells to keep the terminal voltage within a proper range. One or two three-ampere rectifiers of the hot-cathode type are provided as required.

Several plants have been designed to supply energy economically to plates and filaments of repeater tubes, and to other equipment when such energy is not available from regular central office power plants. In order to match more nearly the appearance of the repeater equipment with which these are usually associated, the equipment is mounted on floor-supported vertical channels, which carry shelves and panels. Enclosing covers are being developed for use in locations where appearance will justify the added expense or where additional protection is desirable.

Several small 130-volt plants having a range in capacity from 50 to 80 or from 50 to 200 milliamperes, and larger plants. with a capacity range from 5 to 20 amperes, are included in this series, of which a typical one is shown in Fig. 4. The smaller equipments use copper-oxide rectifiers and reserve batteries of block-type dry cells automaticaly connected into circuit upon failure of the regular power service. An unusual arrangement is employed, the dry cells being connected across the rectifier in series with a copper-oxide disk assembly acting as a valve which permits a very small current to trickle into the cells under normal conditions and interposes but little resistance when the cells pick up the load, automatically sending the current in the reverse direction during power failure.

The larger sized plants use small storage cells as reserve and also use rectifiers of the hot-cathode type. A 24-volt, 8-ampere plant for filament supply is likewise available, and similar plants of other ratings are in process.

Where current demands are heavier, the amount of energy involved and the sizes of batteries warrant the use of ampere-hour meters to start and stop the rectifiers automatically upon a schedule which insures that most of the day's load is carried directly by the charging equipment and that the reserve battery is usually maintained with from 80 to 90 per cent of its capacity available for emergency use. In addition to control contacts and adjustable overcharge shunt, the ampere-hour meter is provided with a thermocouple to increase light-load accuracy, this having been found necessary because during a considerable part of the 24-hour cycle at night the load upon the office is very small. Several sizes of plants of from 5- to 100-ampere capacity at 24, 34 or 48 volts, have been made available.

Four plants have been developed in small and compact shape to furnish economical and automatic ringing and signaling service to outlying offices, particularly of the "magneto" type in districts where subscribers' telephones have their own local batteries. One of these is shown in Fig. 4.

Ringing current is obtained from a motor-driven magneto generator except during failures of outside power when a vibrating-type ringing interrupter operated from dry cells is automatically brought into use. A small storage battery equipped with a copper-oxide rectifier in operation continuously furnishes direct current for the transmitters of the central office operators, this unit being shown upon the lowest shelf.

Larger ringing plants employing two motor-driven generators equipped with a system of interrupters to furnish machine ringing, supervisory tones, and signals, as well as positive and negative direct current for operating coin boxes, have also been developed as completely engineered and coded equipment. The regular set operates from outside power while the emergency set runs on the central office storage battery. Such equipment for a smaller office is shown in Fig. 5.

Automatic-control equipment is so arranged that the emergency set will start upon failure of ringing current from the regular set and all office ringing and signaling circuits will be automatically transferred to the reserve machine by means of 12-pole, electrically-operated switches. The frequency and voltage are automatically controlled and provision is made for return to normal condition as soon as the emergency has passed. Some of the several types of signals provided by these machines utilize interrupted battery current, making slight sparks, so that these interrupters are equipped with radio-frequency choke coils to prevent interference with nearby receiving sets. Later tone alternators of a novel inductor type which cause no interference are also available, together with low-speed interrupters of new design in which the current contacts are made and broken by mercury rolling in cast-iron channels containing an atmosphere of nitrogen.

Some unusual unit-type coded plants with automatic or semi-automatic features have been developed for special uses; only one of these, however, will be mentioned here, namely, the automatic ground-potential compensator for telegraph circuits in telephone offices. This plant, including a regular and a reserve motor-generator set, is arranged to provide a buck-or-boost voltage up to 100 volts or thereabouts in the common telegraph ground lead of an office having this equipment. It is used where unfavorable electrical and geologic conditions cause the local ground potential to fluctuate severely. The machine is controlled by a sensitive high-frequency relay connected over a pilot wire to a neutral ground several miles distant.

OPERATING EXPERIENCE

Some of the automatic-control equipment mentioned has given satisfactory service for several years, but the completely automatic plants of the present types are of recent development. Operation during a few years has been quite satisfactory; any delays under automatic control in general are less than with manual operation, while attendance of course is very greatly reduced. Alarms are provided to secure help from an attended office in the event that any of the automatic equipment should fail to perform or unexpected emergencies should develop. Success with the smaller plants described has led to installation of larger plants upon a trial basis and these also are performing satisfactorily.

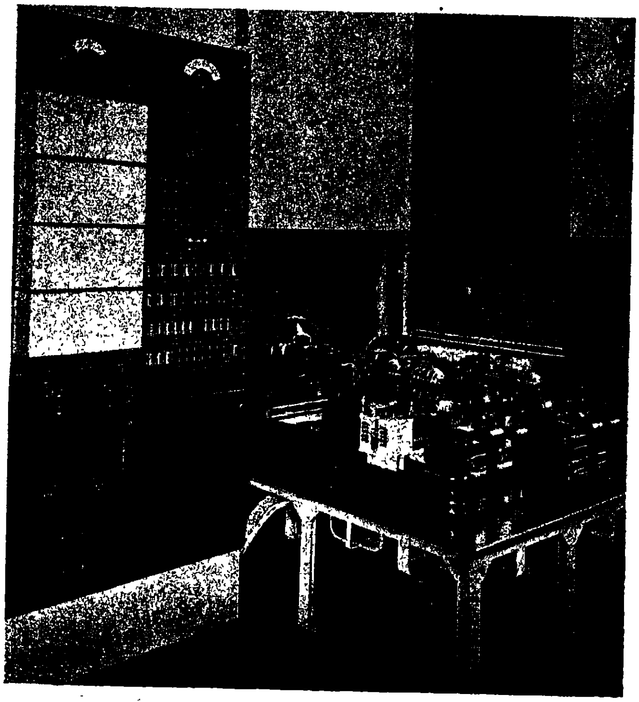


Fig. 5. Power plant for ringing and coin control, 105-100-85-77 volts, 1-8 amperes, 20 cycles and + 110, − 110 volts, 0.25-0.50 amperes direct current

Helical Grooves In Slip-Rings and Commutators

Current-collection problems can be simplified to a marked degree by helical grooves cut into the surfaces of commutators and slip-rings. Results of comparative tests before and after grooving are presented herewith.

By
G. M. LITTLE
Member A. I. E. E.

Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

PERFORMANCE OF BRUSHES on slip-rings and commutators is dependent on many more or less obscure conditions. Some of these are fairly well understood and are under control so that for the most part it is pretty well known what current density, spring pressure, peripheral speed and grade of brush are best for a given brush application. There are many purely mechanical conditions that are undesirable, such as loose commutator bars, worn bearings, poorly balanced armatures, rough tracks (in traction service), friction, vibration, and loose connections; also there are dirt, oil, acid fumes and many other obstacles which influence good brush performance. In addition to these disturbing factors, however, it often is found that the current is not divided evenly between parallel-connected brushes, and this causes some of them to be overloaded.

This article is an account of an investigation into some of the causes of trouble existing right at the sliding contact, and of the series of tests conducted on helically grooved slip-rings and commutators which followed. The results show conclusively that (1) a more uniform current distribution is obtained, (2) local spot heating and glowing under overload conditions are eliminated, and (3) better commutation with cooler operation and longer brush life is assured, where these grooves are employed.

If the current density is high, a brush is likely to glow and throw off white-hot streamers, this glowing manifesting itself as a small stationary or slow-moving white-hot spot in the polished surface of the brush. Of course it cannot be seen directly, but the surrounding brush material becomes heated to a good red color 1/8 of an inch in all directions and if the small white-hot spot is near the edge of the brush, the red glow of the surrounding brush material can be seen readily.

A study of this glowing confirms the correctness of the usual explanation of the cause which is based on the negative resistance-temperature coefficient of carbon. If a brush is overloaded and one part of the brush face should by chance be a little warmer than another part, the current will have a tendency to crowd into this warmer area, raising its temperature more and more until a low-resistance hot spot is developed, which then carries substantially all of the current.

It has been observed that a hot spot of this kind will remain in one location on the brush face for many hundred revolutions of a commutator or slip-ring, during which time all sparking of the brush will be stopped. This tendency of a spot to take all the current and hold to one position on the brush face is promoted further by the local expansion of the hot carbon. This expansion causes the hot spot to become raised slightly above the polished surface and the brush rides on this "hill" until it is worn down. During this time most of the spring pressure is concentrated on the minute, raised area. Local temperature rise due to friction is thus probably a large contributing cause for bringing about the stationary hot-spot condition. When a brush is badly overloaded the hot-spot temperatures may rise to as high as 2,000 deg. cent., sufficient to graphitize the minute areas affected.

With these observations in mind it appeared that if the current passing through the hot spot could be blocked and some other portion of the brush face, or even another parallel-connected brush, could be forced to take the load for a portion of each revolution of the commutator or slip-ring, perhaps a more uniform distribution of current under the brush face and between parallel-connected brushes would result, as well as an absence of local spot heating and glowing.

Two schemes were evolved: (1) a row of side-by-side, straight-around offset grooves; and (2) the helical groove (see Fig. 1). Both schemes were tried out and gave similar results with the exception that the helical groove was easier and cheaper to make and could be cleaned more readily if necessary. In both schemes a given spot on the face of the brush can carry current and can be subjected to frictional heating for only a portion of each revolution of the slip-ring or commutator; during the remainder of the time some other spot or group of spots are forced to carry the load. Any air trapped under the brush face, sometimes a contributing factor in uneven current distribution, is permitted to escape as are any loose abrasive, solid particles of brush or ring material.

LABORATORY TESTS ON SLIP RINGS

The first tests were made to determine the effect of grooving upon contact resistance. Two copper slip-rings were used, one plain and one grooved, both mounted on the same shaft. Each was equipped with

---

From "The Application of the Helical Groove to Slip-Rings and Commutators," (No. 31-38) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

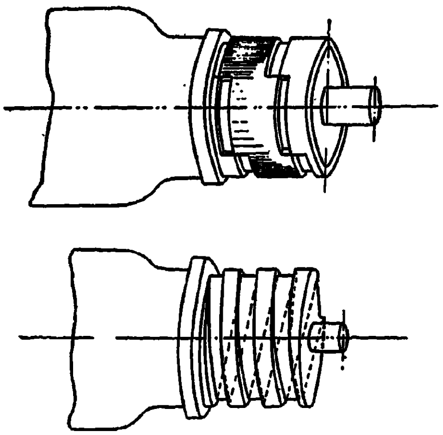


Fig. 1. The two types of grooves treated in this article. (Above) "straight around" offset groove; (below) helical groove

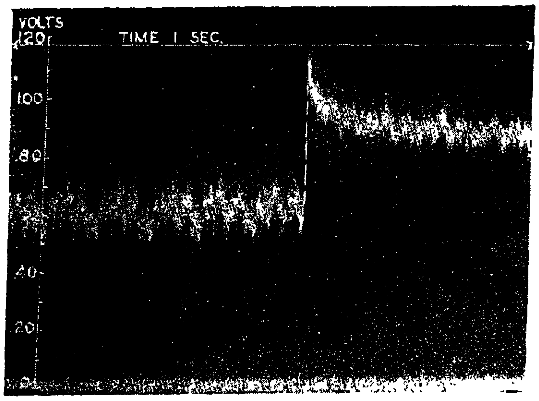


Fig. 2. Change in voltage drop on plain slip-ring as current was suddenly increased from one to seven amperes

Note the high voltage drop during the first fiftieth of a second after change. With the helical groove the current-carrying time of any given brush spot can be limited to less than 1/50 sec. thus maintaining the desirable condition of high contact drop and low operating temperature

one positive and one negative brush and the rings were so arranged that they could be operated either in series or in parallel. At the start, with clean sandpapered rings and brushes, the contact resistance on both the rings was extremely low, but the grooved ring brush-contact resistance was almost always much lower than that of the plain ring. The resistance of both rings then slowly rose until finally after from 20 to 30 hr. the resistance of the grooved ring and brushes became about 20 per cent higher than that of the plain ring and its brushes.

While the difference in the character between the slowly formed surface film of the grooved ring and that of a plain ring is probably the main reason for the difference in the contact resistance (the 20 per cent increase), there is another well demonstrated cause. An oscillogram shows that on a plain ring a sudden, forced increase in current density at the contact between a brush and a ring causes a large but rapidly diminishing increase in the contact resistance (see Fig. 2). It would appear that with a suddenly applied current an appreciable time is required for the temperature of the current-carrying contact spots to rise, during which time the resistance (owing to the negative temperature coefficient) remains comparatively high. The helical-groove scheme furnishes means of control whereby the duration of time that any given spot on a brush face could carry a heating current and maintain frictional contact was limited to 0.02 sec. or less; and from an inspection of the oscillogram as given in Fig. 2 it appears reasonable to believe that this would account for the increase in contact resistance noted.

Another test (made at the laboratory of the Stackpole Carbon Co.) on five parallel-connected metal-graphite brushes on a plain bronze slip-ring gave frequent exhibitions of one or two brushes taking all of the current; later the same brushes run on a grooved ring were free from this trouble.

Further tests were made with a grooved and a plain ring in series and with only one brush on each ring. While the set was subjected to a heavy overload it was observed that while the plain-ring brush sparked badly the grooved-ring brush operated perfectly.

Still another test was made on plain steel rings operating in an atmosphere of hydrogen. Concentration of current and local overheating caused pitting of the brush face and the formation of extremely hard particles (apparently iron carbide) which became imbedded in the face of the brush and rapidly scored the surface of the ring. Grooving this same ring did away with the scoring of the ring and the coarse pitting of the brush face.

LABORATORY TESTS ON COMMUTATORS

One of the first of these tests was made on a defective 2,000-ampere 500-volt d-c. generator. This machine would carry ½ or ¾ load very satisfactorily, but on full load, trouble would develop within a few hours' time, while on 50 per cent overload, glowing, sparking, and streamers would develop at the commutator within ten minutes.

A ⅜-in.-pitch ⅛-in.-wide groove was then cut into the commutator after which the machine carried full load indefinitely (over a week) with no glowing, and withstood the 50 per cent overload for three hours; also it was noted that the grooved commutator ran 10 deg. cent. cooler than the plain commutator. Later this same grooved commutator was operated at full load and 8 of the 44 brushes removed; no distress was observed. This suggested that with grooving, commutators could be built shorter and with less expense.

A long test (200 hr.) was then made on a 40-ampere 500-volt d-c. traction motor, with first a plain and then a grooved (⅛-in. ridge, ⅛-in. groove) commutator. A

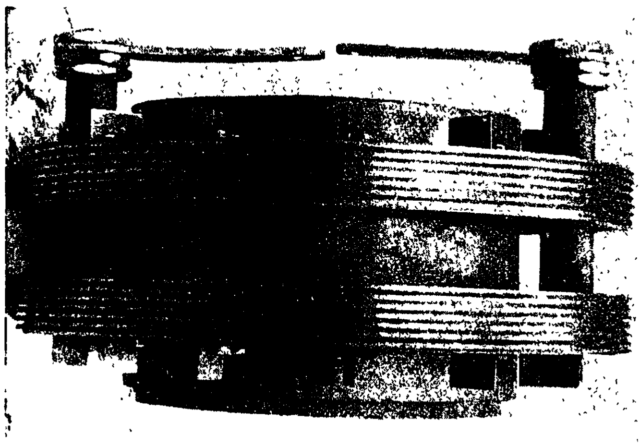


Fig. 3. Grooved slip-rings for a 15,000-kva. hydrogen-cooled synchronous condenser. The grooves are 1/8 in. wide, with a 1/8-in. ridge and a 1/2-in. pitch

reduction in sparking, a seven-degree lower operating temperature, and a more uniform current distribution between parallel brushes were noted after the commutator had been grooved; also the commutator was in better condition at the end of this test than at the end of the test made before grooving.

It appears from the above data that grooving a commutator probably does much more than simply to prevent the formation of hot spots; the cooler operation suggested that the wasteful circulating current occurring under a brush face during ordinary commutation, probably had been reduced. This can be explained only by assuming that the contact resistance had been raised. Reduction observed in the sparking at the trailing edge of brushes on a grooved commutator may be explained also by the increased contact resistance which served to cut down the volume of circulating current which the spark had to handle.

Other Considerations

The depth of groove appeared to have little or no affect upon the performance, although it is reasonable to expect that due to its increased radiating surface and the larger amount of cooling air that is dragged across the brush face a deep groove might promote cooler operation.

Width and pitch of the groove are still being studied; it would appear that to secure the best results in different kinds of service, these dimensions will vary somewhat.

When grooving a commutator it is very desirable to stone the surface after the groove has been cut in and the edges slightly rounded. Any burr left is disastrous to brush life and sandpapering alone is not effective. For subsequent polishing, a very fine sandpaper backed by a wooden block is best.

Commercial Applications to Slip-Rings

The slip-ring tests described were so convincing that when the information was divulged to one of the public service companies, this company decided to cooperate in an experiment on the rings of one of their 13,000-ampere synchronous converters. The operation proved so satisfactory that now another machine is being grooved and put into service. A second public service company is putting into operation a 15,000-kva. hydrogen-cooled synchronous condenser equipped with helically grooved steel slip-rings also running in hydrogen. (See Fig. 3).

The Calculation of Generator Heat Losses

PREDETERMINATION of the temperature in electrical machinery involves three distinct problems: (1) magnitude and distribution of the losses, (2) flow and cooling effect of the cooling medium in the machine, and (3) heat flow from source to cooling medium.

C. Richard Soderberg of the Westinghouse company in a recent A. I. E. E. paper (see foot-note) describes an unique method of calculating heat flow and heat losses within large turbine-generators under conditions of steady temperature. In his ingenious method the author utilizes "equivalent thermal circuits" for solving two-dimensional problems of heat flow.

To the third of the three problems first enumerated the author devotes his paper, which represents "an attempt at a reasonably complete solution for the heat losses in large machines with deep slots, where the temperature drops through the various iron paths are of real consequence. The analysis proceeds by progressive stages of elaboration from a simple conception of the general aspects of heat flow to what is believed to be a fairly correct picture of the complicated phenomena involved.

"Many elaborate mathemtical deductions are given . . . . Several details of the analysis have been carried to a degree of refinement which may be considered impractical for ordinary types of machines. An approximation, however, is justified only when the degree of approximation is known, and this has not always been the case with approximate methods commonly used."

From "Heat Losses in Large Turbine-Generators" (No. 31-33) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931. (For publication in the A. I. E. E. TRANSACTIONS the title of this paper has been revised to read "The Steady Flow of Heat in Large Turbine Generators.")

Synchronizing Salient-Pole Motors

By means of the integraph the differential equation of motion for a synchronous motor during pulling-into-step transients is readily solved. An expression thus can be set up to predetermine the limiting conditions under which such a motor will synchronize.

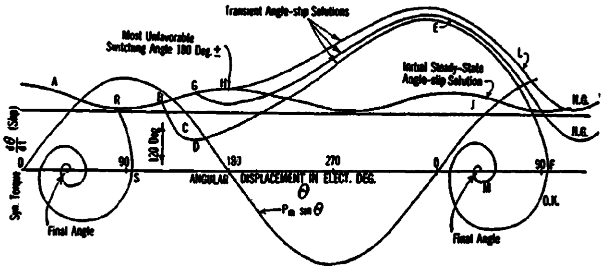
By
H. E. EDGERTON Massachusetts Institute of Technology
Associate A. I. E. E.

PAUL FOURMARIER Massachusetts Institute of Technology
Non-Member

CALCULATION of the pulling-into-step phenomena of a synchronous motor presents one of the knottiest problems in electrical engineering. After a motor is brought up by induction-motor action to as high a speed as is possible, the field is excited with direct current and the resulting synchronizing force tends to pull the motor into step. In case the moment of inertia is small and the shaft load relatively light, the motor will have no difficulty in pulling into step. When synchronous motors are used to drive loads having large torques or large moments of inertia, a condition is approached where the synchronizing force due to the d-c. field will not be of sufficient value to pull the motor into synchronism. The principal object of this investigation was to establish a criterion between the various factors that enter into the problem of the limiting case between satisfactory and unsatisfactory operation, in order that the operation of any particular motor might easily be predetermined.

A consideration of pulling-into-step problems in general for salient-pole motors shows that the following important factors influence the phenomena:

1. Load torque on the motor shaft, which in turn determines the amount of slip when running as an induction motor.
2. Maximum available synchronizing torque, which in most motors is practically proportional to the field current.
3. Inertia of the rotor and connected rotating masses.
4. Effectiveness of the amortisseur windings and field circuit as an induction-motor rotor.
5. The displacement angle between the impressed voltage and the voltage induced by the d-c. field when the exciter is connected.
6. Reluctance torque which is a function of the angular displacement.
7. The degree of unbalance in the induction-motor torque, due to the incompleteness of the amortisseur winding.



Typical integraph angle-slip solution of the equation of motion of a synchronous motor during pulling-into-step transients

All seven of these factors appear in the differential equation of torques and solutions of this equation show their influence.

Until the advent of the integraph calculation of this differential equation was possible only by difficult, approximate methods such as step-by-step analyses and energy relations. The integraph is one of the results of the efforts of V. Bush and others at the Massachusetts Institute of Technology to find mechanical and electrical methods of solving the apparently unsolvable or tediously solvable integral and differential equations which so often are encountered in engineering work.

This investigation is a continuation of a previous study of the conditions for the pulling-into-step of a wound-rotor, synchronous motor.

The details of this investigation were published in the September 1930 issue of the *Journal of the Institution of Electrical Engineers* (London), and by it a criterion for satisfactory synchronization was evolved in terms of the moment of inertia, synchronizing torque, and other factors. The continuation here considers the effects of salient poles and incomplete amortisseur windings, the solution being obtained in a similar manner by means of the integraph.

The conclusion drawn from the study is a relatively simple empirical expression which can be used to represent the pulling-into-step characteristics of salient-pole synchronous motors, this criterion being the following:

$$s < \frac{590}{n}\sqrt{\frac{P_m}{f\,(W\,R^2)}}$$

where s = initial slip as an induction motor.
n = synchronous speed in r. p. m.
f = frequency in cycles per sec.
$W R^2$ = (moment of inertia in lb.-ft.)^2
P_m = maximum synchronizing power in kw. due to the field current.

According to this criterion the amortisseur windings must raise the rotor to such a speed that the average initial slip is less than the indicated function of the speed, frequency, moment of inertia, and synchronizing power, in order that synchronism may result on the first swing for the *most unfavorable switching angle.*

From "The Pulling Into Step of a Salient-Pole Synchronous Motor," (No. 31-48) presented at the A. I. E. E. winter convention, New York, Jan. 26-80, 1981.

One of the conclusions of this study is that the reluctance torque does not influence the value of the criterion to any considerable extent. The reason for this is that the reluctance torque makes the initial slip more unfavorable than it would be if it were not present (as in wound-rotor machines) but a greater synchronizing effect is exerted by the joint action of the reluctance and synchronizing torques. These two opposite influences of the reluctance torque tend to cancel, and therefore its net effect on the ability of the motor to synchronize is inappreciable.

The degree of unbalance of the damping winding apparently also has a rather minor effect on the critical ratio. This is undoubtedly due to the fact that the rotor swings through such a large range of values of angle that only the average damping is of importance.

By means of the criterion equation, calculations of limiting slip were made for a 160-hp. synchronous motor, and according to these calculations the maximum value of slip at which the motor would pull into step was 0.0143. This represented the limiting value for the worst switching angle. In laboratory tests at these most unfavorable switching angles, the value of slip at which the motor would actually synchronize varied from about 0.014 to 0.015, which is in very close agreement with the calculated value.

A Concentrator for Printing-Telegraph Circuits

The termination in a telegraph office of a large number of "start-stop" printing telegraph circuits, requires some means for concentrating the circuits to enable incoming and outgoing traffic to be handled efficiently and economically. A multiple-turret concentrator which permits any one of many circuits to be worked by any one of a few operators is described here.

By
WILLIAM B. BLANTON The Western Union Telegraph Company
Non-Member

DURING recent years great improvement has been made in printing telegraph systems which employ the start-stop method of synchronism. Printers adapted to such systems are known by various names, some of which are start-stop printer, simplex printer, teletype, telephone typewriter, typing telegraph and teleprinter.

The telegraph companies are using in increasing numbers printers of this type on circuits which connect to the central telegraph office the public-branch offices within a city as well as the offices of those patrons who have sufficient message traffic to warrant the telegraph companies incurring the expense of providing such a connection.

The majority of such circuits is worked intermittently and therefore the continuous services of an operator are not required at the operating terminals of each circuit. In order to handle efficiently and economically the traffic on a large number of these circuits which enter a telegraph office, there is required some means for concentrating the circuits so that any one of a large group can be worked by any one of a smaller group of operators.

Before the equipment described in this paper was decided upon, three methods of concentration were considered; (1) automatic switching of calling lines to idle operators, (2) manual switching by an arrangement somewhat similar to a manually-operated telephone private-branch exchange, and (3) lines multipled before each operator.

A study of the economics and operating advantages of these three methods, and their adaptability to the present methods of handling telegraph traffic, led to the choice of the latter arrangement; in other words, a multipled-turret concentrator.

A general view of a typical concentrator installation having 50 operating positions and a capacity of 100 lines is given in Fig. 1. It is not intended that the line capacity of this type of concentrator be limited to 100 lines; in fact installations already have been made of 200 line concentrators, and it is quite practicable to accommodate more than 200 lines with the use of the same type of equipment. The number of operating positions provided depends upon the traffic load and is determined individually for each concentrator. In actual installations of 100 line concentrators the number of operating positions has varied from 20 to 70.

All of the lines to be worked in a concentrator appear in a turret (*B*) at each operating position. These turrets are simply small switchboards connected in multiple.

Associated with each line is a relay arrangement

From "A Printing Telegraph Concentrator," (N . 31-1) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

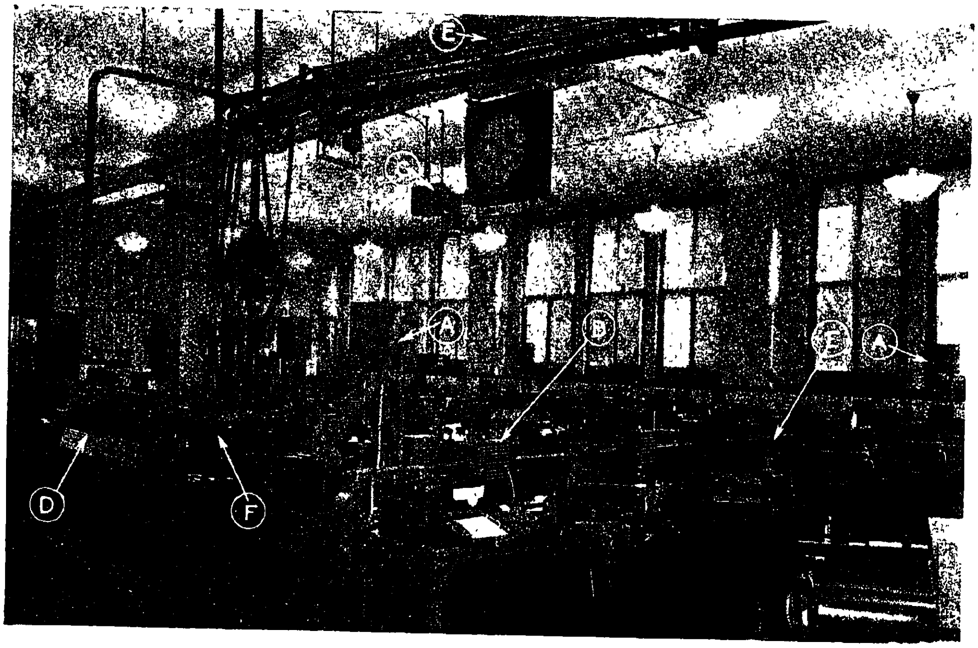


Fig. 1. General view of a telegraph concentrator showing:

A—Calling-lamp cabinet
B—Turret
C—Idle-operator indicator
D—Message routing rack
E—Message conveyer belt
F—Message drop

which serves to light the calling lamps when the outer office initiates a call. This equipment must also function to extinguish the calling lamps when an operator answers the call and must be restored to the condition where it will be in readiness to receive another call when the operator disconnects. Generally, in multiple-turret arrangements this relay device is controlled from the operating positions over a conductor separate from the line circuit, thus necessitating that an extra conductor for each line be multipled from turret to turret. Since the cost of the turrets and the cabling required to connect them in multiple is a large item in the total cost of a multipled-turret concentrator, particularly when the ratio of turrets to lines is as high as 70 or 100 an endeavor was made to simplify the turrets and reduce the number of conductors in the multiple. To this end, the concentrator is designed so that the turret multiple comprises only one conductor for each line, the control of the relay equipment which actuates the calling lamp being accomplished over the line conductor.

The use of the one conductor multiple permitted a departure from common practise in the design of the turret. Instead of jacks, the line conductors are terminated on studs molded in bakelite panels. Fig. 2 shows a 100-line turret equipped with two of these panels; over each stud will be noted the line designation. The major advantages of these panels over an equivalent arrangement of jacks and designation strips are reduced cost of apparatus and installation, and saving of space by use of a shallower turret.

Instead of associating a calling lamp with each line stud in the turrets, the lamp cabling is greatly simplified by distributing calling-lamp cabinets containing one lamp for each line among the operating positions so that each cabinet is visible to, and used by, a number of operators.

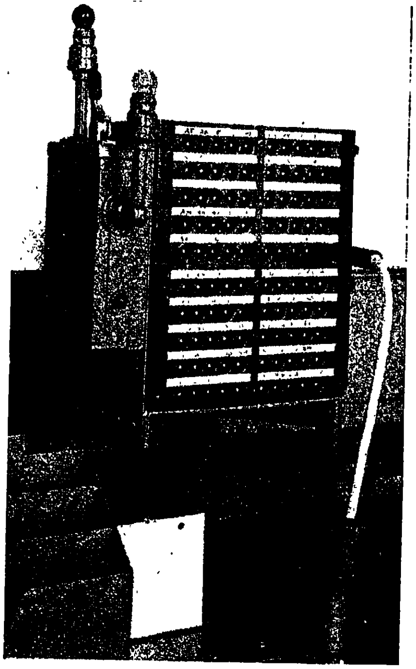


Fig. 2. Signal assembly and 100-line turret

The printer apparatus at each operating position (Fig. 3) is included in an operator's cord circuit which terminates in a jack-plug (*P*), so termed because it is used like a plug but contains springs which operate like jack springs. It is by connecting the jack-plug to a line stud in the turret that an operator connects that printer to any desired line.

When an operator at an outer office initiates a call, the calling lamps associated with this line in all of the lamp cabinets light. To avoid the confusion of all of the idle operators endeavoring to answer the call, and at the same time make sure that the call is answered promptly, the responsibility for answering is placed by virtue of an "answer-next" system upon the lowest-numbered idle operator. This system provides an answer-next lamp (*N*) on each operating position. Only one of these lamps in the entire concentrator is lighted at a time, and that lamp is always located before the lowest-numbered idle operator. This lamp glows steadily when there are no calls and flashes the instant a call appears. The operator then refers to the nearest lamp cabinet (*R*) and proceeds to attach the jack-plug to the line stud having the same relative location in that turret (*O*) as the lighted calling lamp has in the lamp cabinet. Immediately after the operator has made the connection, the answer-next lamp is extinguished and the lamp in front of the next lowest-numbered idle operator will light.

The printer (*T*) is a tape printer. During the reception of messages the operator gums the tape of each message on a telegram blank, stamps the time on the blank and then places it on a belt conveyer (*H*) which runs along the rear edge of the operating table. This conveyer feeds into a conveyer system that carries all received messages (including those received by other facilities) to the main routing center of the office.

All messages received at this main routing center and destined for an office the line of which terminates in a concentrator are dispatched by a conveyer to a message-routing rack centrally located at one end of the table rows of the concentrator as shown in Fig. 1. One or more clerks then sort these messages, according to their destination, into the proper compartment of the message-routing rack which has one compartment for each line terminating in the concentrator. Other clerks called "routing aids" immediately take these messages out of the rack and carry them to concentrator operators; messages for an office the line for which is busy are taken to the operator then working that line, while messages for an office with line idle are taken to an idle operator.

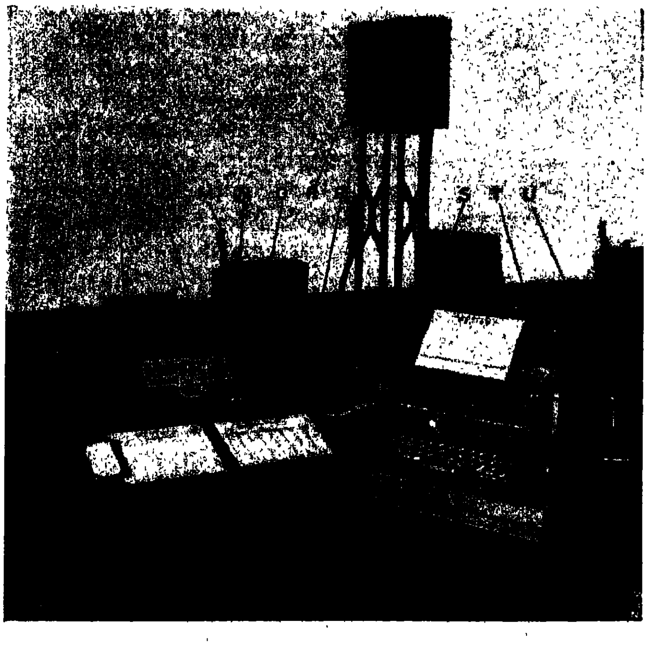


Fig. 3. A concentrator operating position

H—Belt conveyer
J—Time stamp
K—Gumming desk
L—Busy-line lamp
M—Idle-operator lamp
N—Answer-next lamp
O—Turret
P—Jack-plug
R—Calling-lamp cabinet
S—Live-message file
T—Printer
U—Number stamp

Fig. 4 shows the front view of a message-routing rack provided with 100 compartments; underneath each compartment are located five lamps utilized by the routing aids in locating the operator working any particular line. Referring to Fig. 1 it may be noted that the operating tables are divided into five distribution groups. When a line is busy, one of the five lamps associated with this line at the message-routing rack is lighted, that particular lamp denoting in which distribution group the operator then working that line is located. Thus the routing aid is guided to the proper group of tables, views the turret on each busy position, and ascertains by the location of the jack-plug which operator is working the line in question.

If none of the lamps under a particular compartment is lighted, the associated line is idle. When removing a message from such a compartment, the routing aid looks at an idle-operator indicator which is generally suspended from the ceiling and located just to the rear of the routing rack. By means of lamps this indicator shows the location of all the operators idle at that moment. As a further aid to locating the idle operators, each operating position is equipped with a green light (*M* in Fig. 3) which shows when the operator is idle.

Occasionally a message may be handed to a concentrator operator for transmission to an office which at that moment is being worked from another concentrator position. Since no busy lamps are included in the turrets, the operator is not aware of this busy condition and plugs in on the line stud. The cord circuit, however, contains an arrangement which automatically prevents the printer equipment from being connected to

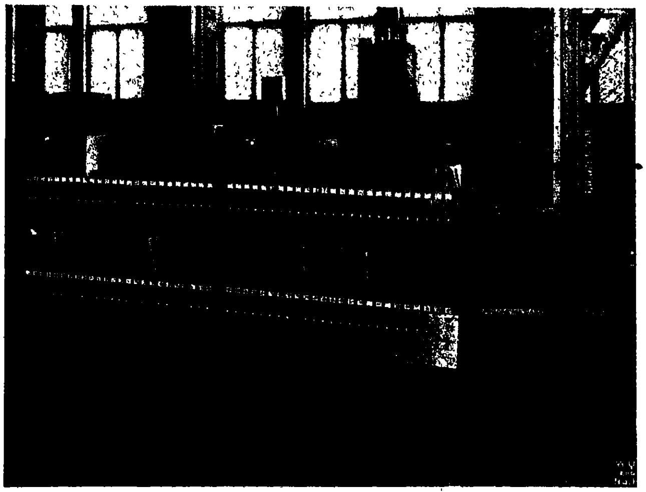


Fig. 4. Front view of message routing rack

a busy line, and furthermore, this arrangement is such that no interference is caused to printer signals which may at that moment be passing over the line circuit. The fact that the plugging in has been done on a busy line is indicated to the operator by the lighting of the busy-line lamp (*L* in Fig. 3). If the operator fails to see this signal and attempts to send on the printer, the printer due to the fact that the motor is not running will not function.

Several supervisory lamps are conspicuously located at some point about the concentrator; these lamps serve to warn the supervisor of conditions which require immediate attention, such as calls not being answered promptly or an insufficient number of operators.

All start-stop printing telegraph circuits entering the larger telegraph offices are terminated in concentrators even though some of these circuits require the individual attention of an operator during the greater part of the day.

Because the lines are of various lengths and characteristics, it is necessary to equate them for termination in a concentrator. Short lines are terminated directly in a concentrator multiple. The longer lines are terminated in single-line or duplex-half repeaters or terminal-duplex sets, the local sides of which are connected to the multiples.

Brazed Joints for Electric Conductors

Electric resistance brazing produces in electric conductors joints which possess several distinct advantages over equivalent soldered joints, and in addition can be made at a lower cost. A description of the equipment and process is given with comparative results between the two types of joints.

By
SAMUEL MARTIN, JR.
General Electric Co.
Schenectady, N. Y.

ELECTRIC RESISTANCE BRAZING has been developed to meet the need for a better means of joining two electrical conductors. Not only have brazed joints higher heat resisting qualities and higher mechanical strength than soldered joints, but they possess high electrical conductivity as well. The simplicity of the brazing process is well illustrated by the following brief description: the parts to be joined are first clamped between a pair of carbon blocks; current is then passed through these blocks and the joints, thus heating the blocks and the parts to be joined to the melting point of the brazing alloy. The alloy, which for convenience is usually in the form of a thin strip, is then applied to the contact surfaces, is melted, and flows through the joints, uniting the parts into a solid mass.

The equipment required for making this type of joint is equally simple, consisting only of an air-cooled transformer with primary and secondary leads (the latter being connected to the brazing tongs), a foot switch, and specially designed clamping tongs for holding the work. Special transformers were designed to meet the many varying factors encountered in this work. In order to heat the parts to be brazed quickly, high current is required in the secondary circuit which is subject to momentary overloads of as high as 400 per cent. With these high currents a small reactance in the leads between transformer and tongs affects the power factor materially. For any given length of lead (7-ft. being recommended), the type of carbon block, kind of joint, and amount of contact between blocks and joint also affect the power factor.

For conductors up to 300,000 cm. in cross-section, a 5-kva. transformer has been found satisfactory; for conductors from 300,000 to 2,000,000 cm. in cross-section, a 10-kva. transformer has been found a convenient size.

The complete equipment for making joints on conductors up to 2,000,000 cm. in cross-section weighs less than 100 lb.; hence it can be transported easily from place to place. For larger joints stationary machines or presses have been adopted using much larger transformers.

Proper preparation of the work for brazing is of prime importance. Parts to be brazed should be as flat as possible so that the carbon blocks will come into intimate contact with the entire surface, thus guarding against arcing and hot spots between the blocks and parts being joined. In joining round or irregularly shaped pieces the carbons may be cut to fit the piece. In general, flat plate terminals (see Fig. 2) will replace the tubular terminals commonly used in soldered joints. If the flat plate terminal

---

From "Electric Resistance Brazing," (No. 31-16), presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

or busbar is more than 1 in. wide, it is slotted and the brazing operation performed on each individual section as a separate operation.

Standard cable is usually prepared by wrapping with thin copper strip or inserting the end of the cable into a thin copper tube; then flattening before clamping in the tongs. If a very flat joint is desired the thin copper strip should be wound around the strands rather loosely. In all cases the wrapping or tubing should extend from ½ to 1 in. beyond the portion being brazed. Copper braid is prepared in a somewhat similar manner as may be noted in Fig. 2. In this case a copper clip about 0.02 in. thick and slightly wider than the braid is placed on the end of the braid, extending about ½ in. beyond the contact surface. Depending upon the size of the cable, insulation should be removed for a distance of ½ in. to 2 in. from the joint, the bare cable being wrapped with damp asbestos to protect the insulation from overheating during the brazing process. Flat joints are made by lapping the pieces to be brazed about 1½ times the thickness of the conductor. If it is desired to make a butt or scarf joint on rectangular conductors, this can be done by clamping the two ends together, then applying the carbon blocks to the edges of the conductor and feeding the alloy in from the flat side.

In soft soldering it is very essential that the surfaces be clean and free from oxides or other impurities. This is not so essential in brazing but certain oils and varnishes are not attacked by the brazing flux and should be removed. Generally fused borax is used for the flux, and it may be applied either in dry powder form from a small sifter or mixed with water or vaseline and applied to the joints in paste form. Depending upon the joint to be made, three different silver alloys are used as a brazing medium; these contain respectively 10, 20, and 50 per cent of silver. Alloys containing the higher percentages of silver have a lower melting point (about 730 deg. cent.) and are consequently used on small parts where temperatures must be kept down to a minimum. The 10 per cent silver alloy is satisfactory on larger cables, terminals, and busbars, where a higher brazing temperature (830 deg. cent.) is not objectionable.

The economics of adopting brazing in place of soldering are sound. Many cost studies have been made on various sizes of cables, plates, bars, and other conductors, and for purposes of comparison three typical cases are presented in Table I.

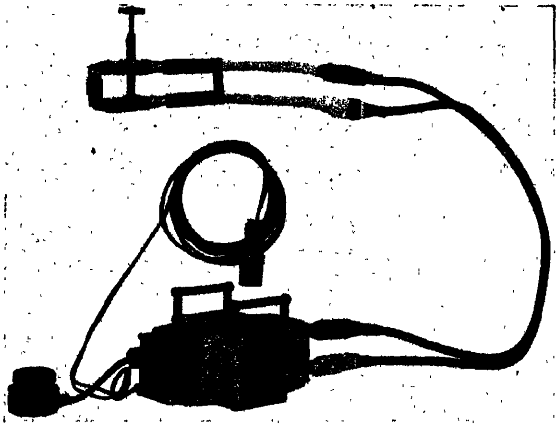


Fig. 1. Complete resistance-brazing equipment with 10-kva. transformer having 8-, 10-, and 12-v taps on its secondary winding

TABLE I—COST COMPARISON BETWEEN BRAZED AND SOLDERED JOINTS

Case	Preparation time	Brazing or soldering time	Finishing time	Cost of alloy or solder	Cost of labor at 60c./hr.	Total cost
1-B	3.41	3.17	1.2	0.027	0.077	0.104
1-S	3.41	5.17		0.025	0.085	0.110
2-B	10.90	7.28	4.0	0.225	0.220	0.445
2-S	10.99	17.97		0.247	0.288	0.535
3-B	5.35	15.57		0.225	0.209	0.434
3-S	5.35	24.80		0.46	0.302	0.762

In the column headed "Case,"
B—Brazed joint
S—Soldered joint
1—Terminal joined to 180,000-cm. cable
2—Terminal joined to 1,500,000-cm. cable
3—Twelve 1/8-in. by ¼-in. conductors are joined to a 770,000-cm. cable

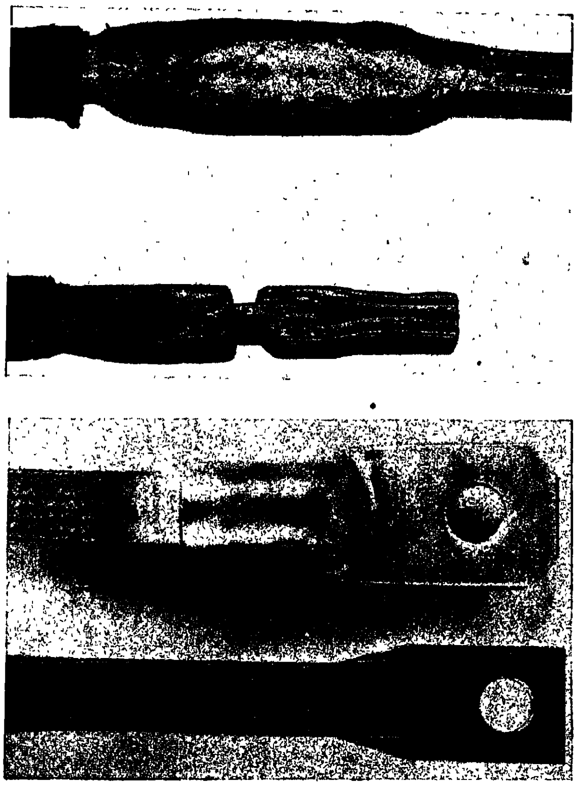


Fig. 2. A comparison between brazed and soldered joints; (above) two large conductors joined together; (below) brazed flat plate terminal and soldered tubular terminal on copper braid

In this table the preparation time includes skinning, binding, and forming the cable; finishing time is that required for cleaning. These costs have been computed for soldering under the most favorable conditions; if labor were figured at 90 cents per hour the saving on that item would be much greater.

In addition to their economic advantages brazed joints present several other distinct advantages over soldered joints. When silver solder is applied to a copper joint it dissolves a thin film of the copper surface which is very rich in copper; hence it is an excellent conductor of electricity. Since the melting point of this alloy is higher than that of the silver solder a higher temperature is always required to open the joint than to form it. If the lapped joints are designed in each case to have a contact area of at least 1½ times that of the conductor cross-section, the factor of safety is such that the joint will carry as much overload as the conductor itself. In Fig. 2 it may be seen that brazed joints besides being much more accessible for inspection are much smaller than soldered joints. These factors together with the improved mechanical strength and durability of brazed joints mark another distinct step forward in the electrical industry.

A Vacuum-Tube Voltage Regulator

A device has been developed which not only provides voltage regulation for alternators, but short-circuit protection as well. Saturation current from the filament of a thermionic tube forms the control element, while stabilization is accomplished by a feed-back system.

By

L. C. VERMAN Associate A. I. E. E. — Cornell University, Ithaca, N. Y.

L. A. RICHARDS Non-member — Cornell University, Ithaca, N. Y.

VACUUM TUBES have come into general use during the past few years for controlling and regulating various types of electrical apparatus where extremely accurate regulation of speed, voltage, or other factors, is required. These applications have been confined in general to small apparatus, but few attempts having been made to adapt such means of regulation to meet the needs of large power units.

Recently, however, a regulator of this type was developed by the physics department of Cornell University, and has been in use for about two years in the laboratory on a 25-kw., 110-volt, d-c. generator. This regulator has required no readjustments or replacement of parts.

Encouraged by this performance, a similar voltage regulator has been developed for use on alternators. Operation of this regulator involves conversion of a-c. line-voltage fluctuations into corresponding d-c. variations, amplifying these and applying them to the field of an exciter which supplies the main alternator field, thus controlling the line voltage.

A schematic diagram of the regulator circuit is shown in Fig. 1. As may be noted, the amplifying system is of the ordinary resistance-coupled type. All the grid bias and plate voltages are supplied by a single "B-eliminator" system operated from the alternator being regulated. Tube filaments are lighted directly by alternating current through individual transformers also supplied from the generator under regulation.

The first tube (in this case a UX-210 type) is operated at a low filament temperature and high plate voltage, so as to obtain saturated plate current. Under these conditions the current through the coupling resistance R_2 is nearly independent of the plate voltage but changes rapidly with the filament temperature and hence with the r. m. s. value of the line voltage. This scheme was found to be superior to a grid-control method since the grid potential must be obtained from

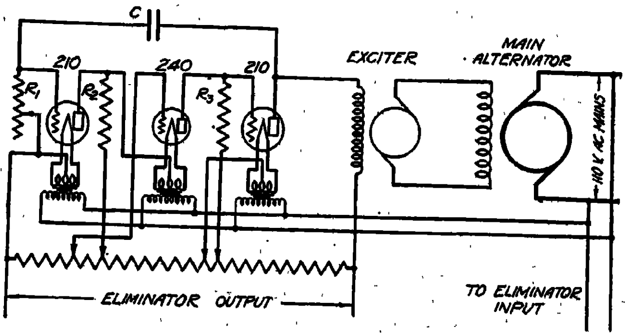


Fig. 1. Schematic diagram of regulator

From "A Vacuum-Tube Voltage Regulator for Alternators" originally submitted to the A. I. E. E. and subsequently published in full in the *Review of Scientific Instruments*, Oct. 1930.

the B-eliminator output voltage which is more closely related to the average rather than the r. m. s. value of the line voltage.

Voltage drop across R_2 is balanced out by a small adjustable portion of the eliminator output and is then applied to the grid of the second tube—a high-μ, UX-240 type. Thus a decrease in the line voltage makes the grid of the second tube more negative, cutting down the current through R_3, which makes the grid of the last tube more positive thereby building up its plate current. This increases the exciter voltage, builds up the main alternator field and boosts the line voltage. An increase in line voltage simply reverses this process.

A UX-210 type tube is employed in the last stage of the amplifier to supply the field current to the exciter generator whose field is wound to match the d-c. plate resistance of the tube. This field winding is the only special piece of apparatus used in the entire system, all the other parts being of standard make and readily obtainable.

Since the vacuum-tube system is almost instantaneous in its response to small fluctuations, the original regulator with the high amplification required for regulating a-c. machines was rather unstable in its operation. This condition, together with the comparatively long-time lags in the fields of the exciter and the main alternator, caused hunting, *i. e.*, oscillation of the line voltage about a mean value. After a good deal of experimentation it was found that the regulator could be stabilized by a feed-back coupling system composed of a condenser C and a resistance R_1, which reacts on the grid of the first tube. This virtually delays the response of the regulator, thus cutting down its tendency to over-correct.

PERFORMANCE TESTS

A number of experiments was made with this regulator connected to a 35-kva., 220-volt, two-phase alternator, operated as a single-phase machine at 110 volts —this being the rated voltage of the eliminator equipment. This constituted a severe test for the regulator, because for a given load the field-current correction necessary to maintain constant voltage is greater for low than for high voltages.

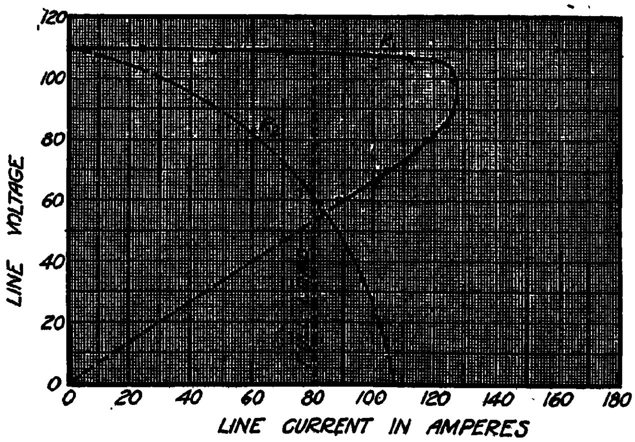


Fig. 2. Voltage characteristics of an alternator with unity-power-factor load; R_1 with vacuum-tube control; R_2, fixed excitation, without regulator

The characteristics of terminal voltage with load current at unity power factor, with and without the regulator, are given in Fig. 2. It may be noted that at full load with the regulator, the terminal voltage drops only 1.5 volts as compared with a 50-volt drop with fixed excitation.

Oscillograms (see Fig. 3) were made showing the line voltage, line current, and field current when full load at unity power factor was suddenly applied and then suddenly dropped with the regulator in operation. In these tests a regulating transformer was used to supply the B-eliminator of the regulator. This transformer was developed especially to maintain constant output voltage for a wide range of primary voltages, the load remaining constant.

With the regulating transformer in use, however, an added load of fifteen amperes at a low power factor was imposed upon the alternator and consequently the *percentage* regulation was not quite so good as when the transformer was not in use.

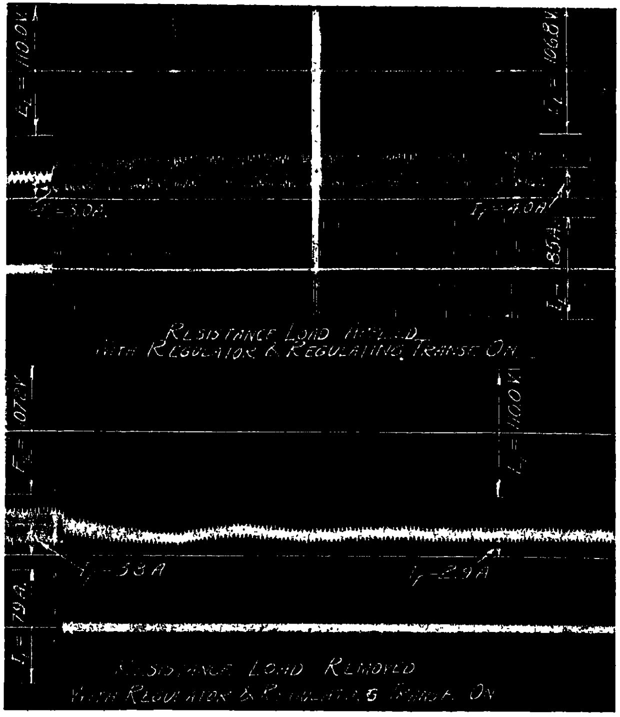


Fig. 3. Alternator terminal voltage, and field and load currents with regulator and regulating transformer in use; (above) full load is suddenly applied; (below) the load is cut off

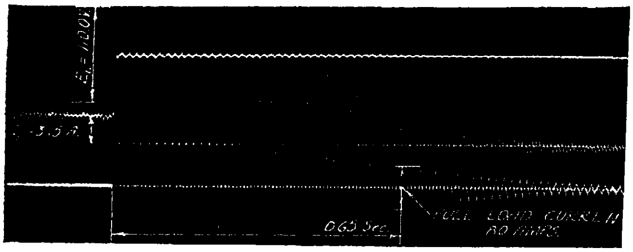


Fig. 4. Alternator voltage and current relations at time of short circuit. Note that field current is rapidly reduced to a negligible value by the protective action of the vacuum-tube regulator

PROTECTIVE ACTION

Referring again to curve R_1, Fig. 2, it may be noticed that at about 50 per cent overload the voltage starts to decrease rapidly. This is due to the fact that the B-eliminator output and the temperature of the first-stage tube filament drops sufficiently to make further regulation impossible. After the point of maximum current is reached, the system becomes unstable and the voltage drops rapidly back to zero, thus providing overload protection for the generator. The amount of overload at which the relay action starts depends upon the regulation characteristics of the eliminator as well as upon the average operating temperature of the first tube filament.

An oscillograph record showing the transient conditions occurring at short circuit with the regulator and regulating transformer in operation, is presented in Fig. 4. As may be seen, the short-circuit current is reduced to full-load value in about 0.6 sec.

FIELD CURRENT

It is shown also in Figs. 3 and 4 that the field current of the alternator is not a steady, direct current but has superimposed upon it a strong 120-cycle current. This comes from two sources: First, since the filaments of the tubes are lighted directly from the alternator, plate currents of all tubes contain a 120-cycle component which is carried right through the exciter to the main field. Second, the single-phase, 60-cycle current flowing through the windings of the armature of the main alternator induces in its field a 120-cycle e. m. f.

This 120-cycle component in the field current is of advantage, however, since the magnetic circuits of the exciter as well as the alternator are continuously carried around a hysteresis loop, thus making the average magnetic flux, and hence the generated voltage, always a single valued function of the d-c. component through the field. This field current ripple, being an even harmonic, causes no distortion in the wave form of the output voltage.

FURTHER PROBABILITIES

The regulator here described furnishes an indication of what may be accomplished by means of vacuum-tube control for power equipment. It is realized that the design might be varied to accomplish purposes other than the simple control of a single-phase machine. For example, compensation for line-voltage drop could be introduced by means of an extra winding in the filament transformer of the first tube, this winding having all or a part of the line current flowing through it. In the case of polyphase alternators a variety of schemes could be used for arranging the transformer or transformers supplying the control filament, depending upon what system voltage it is desired to control.

Motive Power for Suburban Electric Lines

Low annual car mileage together with the large number of cars required make the economical handling of suburban passenger traffic difficult. Results of a comprehensive analysis of the problem are presented.

By
CHARLES KERR, JR. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Non-Member

MAIN-LINE RAILROADS are continually becoming more important factors in providing for the rapidly increasing suburban traffic in the larger cities. Like all urban transportation, this traffic due to the poor load factor which results from the heavy rush hour peaks, places a severe burden on the railroads. These peaks are of such magnitude that the rolling stock required to provide for this traffic is from two to six times that required for the base load. On the other hand the annual mileage of suburban cars is very low compared with that of cars in through service.

An extended suburban system embraces a variety of different types of service conditions for which the motive power must be sufficiently flexible. The average length of runs vary from a mile or less to over ten miles; the train make-up, from a few cars to many. For these

---

From "M tive Power for Suburban Electrification," (No. 31-18) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

varying conditions electrification is ideally suited, and the series motor with its steep speed-tractive effort curve meets the requirements of this service. For the short runs where high acceleration is desirable, this type of motor will deliver high tractive efforts with minimum demands on the distribution system. For the long runs where high-speed operation is desired, it will provide high balancing speeds. The steeper the speed-tractive effort curve, the better the motor is adapted to this service, a feature which makes the a-c. commutator motor well suited to suburban electrification.

The flexibility of multiple-unit cars enables trains of varying lengths to be easily formed and if desired the schedule speeds can be made independent of train size.

Modern practise in suburban electrifications employs accelerating rates not to exceed 1.0 to 1.5 mi. per hr. per sec. and maximum speeds of approximately 70 mi. per hr. Due to wheel slippage the maximum acceleration practical with two-motor equipment or four-motor equipment and a trailer is approximately 1.5 mi. per hr. per sec. The maximum speed may be raised to 90 mi. per hr. or more; but the advantage to be gained from this is small and the expense disproportionately large.

Previously it was mentioned that the annual mileage of cars in suburban service is quite low. On some systems the average is only about 25,000 mi. per car per annum, while the average for the entire country is only about 35,000 mi. Because of this low mileage, the fixed charges are the largest item of expense, and in some cases may exceed per car mile the combined cost of power, maintenance, and crew expense. With the electrical apparatus available today it is possible to reduce the operating costs greatly without materially handicapping the car performance. This may be accomplished in three ways.

LARGEST CARS MOST ECONOMICAL

The most economical car is that with the largest capacity which can be operated within the existing clearances. As the seating capacity of a car is increased, the cost, weight, and horsepower capacity per seat decrease, thereby reducing the power consumption, maintenance and fixed charges per seat. The chief objection to the large car however is its lack of flexibility. This objection is not so serious as it would seem, for most large electrifications today are faced with the problem of increased train length; with this increase the large car in spite of its lack of flexibility can be used to advantage. It is true that train make-up during the off-peak hours is slightly handicapped, but any increase in power during such times which might result from slightly heavier trains is more than counterbalanced by the reduced fixed charges. Recently there has been a decided tendency to reduce the car weight through the use of aluminum alloys, since a reduction in weight reduces the power consumption, and also the motor capacity. It is estimated that the saving of one pound reduces the operating costs per annum from 2.5 to 3.0 cents with an average car mileage of 35,000. Assuming 10 per cent fixed charges, it is economical to invest from 25 to 30 cents to save one pound in weight.

With any system of electrification in use today it is possible from a constructional standpoint to install on a car axle all the power which it is practical to utilize. This increased power may be employed either by increasing the schedule speeds or by handling trailers.

On large systems the average length of run is between 1.0 and 1.5 mi.; with acceleration of 1.0 mi. per hr. per sec. and a maximum speed of 70 mi. per hr., schedules from 20 to 40 per cent better than those with steam power can be maintained. An increase to 1.5-mi.-per-hr-per-sec. acceleration will increase the schedule speed only 3.3 per cent and will require motors 30 per cent larger. Likewise a 1.5-mi. per hr. per sec. acceleration and 90 mi. per hr. safe speed will increase the schedule speed only 6.6 per cent with a required increase in motor capacity of 67 per cent.

Because of the fact that the increase in schedule speed above a certain point is out of all proportion to the increase in motor capacity, it would appear to be highly economical to employ this increased capacity to handle trailers, thereby reducing the power consumption, maintenance, and fixed charges. During the off-peak hours sufficient motor cars will be available to provide all-motor-car operation which is desirable at these times. Power is relatively inexpensive as it does not increase the peak load demand; therefore any improvement in traffic resulting from better service is practically net profit.

As an illustration of trailer operation, a ten-car train composed of all motor cars will make only 3.3 per cent better schedule time than six motor cars and four trailers. In order to attain this 3.3 per cent increase in speed, an increase of 59 per cent in motor capacity is necessary. Costs of power, maintenance, and fixed charges are 22 per cent greater to deliver the *average* passenger at his destination less than *one minute* earlier.

To summarize, the most economical method of handling suburban traffic with electric motive power is, (1) to use the largest cars which can be operated within the existing clearances; (2) to reduce car weight, and (3) to operate all-motor-car trains or the equivalent during the off-peak hours with the extensive use of trailers during rush-hour periods.

LOCOMOTIVE OPERATION

On railroad systems operating extensive electrifications, the use of locomotive power on the heaviest trains may be desirable in suburban express service where the distance between stops ranges from three to ten miles. Due to the factor of diversity, locomotives may be operated both in through and suburban service with a large annual mileage, so that the fixed charges are low, making this operation economical. For short runs and small trains and when the annual locomotive mileage is low, multiple-unit cars offer better service at less expense.

News
Of Institute and Related Activities

Last Call for
The Summer Convention

ARRANGEMENTS are complete for the A. I. E. E. summer convention to be held in Asheville, N. C., June 22-26, with headquarters at the Grove Park Inn. Situated high in the southern Appalachians, Asheville offers scenic splendor of unusual interest to those who have not heretofore visited that city.

An excellent technical program has been arranged consisting of seven sessions on subjects of broad scope and current interest. Three of these sessions are symposiums; one on the important subject of power system interconnection, another on the interesting topic of communication systems for electric utilities, and the third dealing with history of electrical units, the volt, the ampere, and the ohm. Also there will be sessions on power cables, automatic stations, electrical machinery, and research.

The general convention committee has arranged an excellent series of entertainment features, sports, and inspection trips to afford visitors an attractive week of enjoyment. On Monday evening the president's reception will be held; Tuesday evening there will be a get-together dinner with entertainment; Wednesday evening the convention banquet will be given. All of these events will be held at the Grove Park Inn convention headquarters and each will be followed by dancing.

A complete list of events, tentative technical program and a description of the inspection trips was published in ELECTRICAL ENGINEERING, May, 1931, pp. 368-371. The few minor changes in program completed since the first announcement are outlined in the following paragraphs.

TECHNICAL SESSIONS

"Field Transients in Magnetic Systems" by Ernst Weber of the Polytechnic Institute of Brooklyn, N. Y., has been added to the Tuesday morning session on electrical machinery. "Residual Air and Moisture in Impregnated-Paper Insulation III" by J. B. Whitehead and F. Hamburger, Jr., of the Johns Hopkins University, Baltimore, has been transferred from the research session to the Thursday morning cables session.

GOLF—SPECIAL TOURNAMENT RULES

For golfers the main event will be the annual tournament for the Mershon Trophy, to be played over the excellent 18-hole course of the Biltmore Forest Country Club. This club is about three miles from the center of Asheville in the heart of the Biltmore Forest development. It is surrounded by beautiful homes and from almost every point there are beautiful mountain views.

It is essential that the qualifying round of the Mershon Trophy tournament be completed; this will mean that guests arriving after Monday will be unable to enter this competition.

The competition will consist of qualification round of eighteen holes, (handicap medal play) followed by match play (handicap).

The sixteen low net scores will qualify for the match play rounds, which will be played Tuesday afternoon, Wednesday afternoon, and Thursday, morning and afternoon.

Arrangements will be made by the committee for officers, section delegates, *et. al.*, to play their qualification rounds at any convenient time on Monday, so as to avoid missing their scheduled meetings.

No greens fees will be charged members or registered guests during the convention; transportation to and from all courses will be provided.

TENNIS

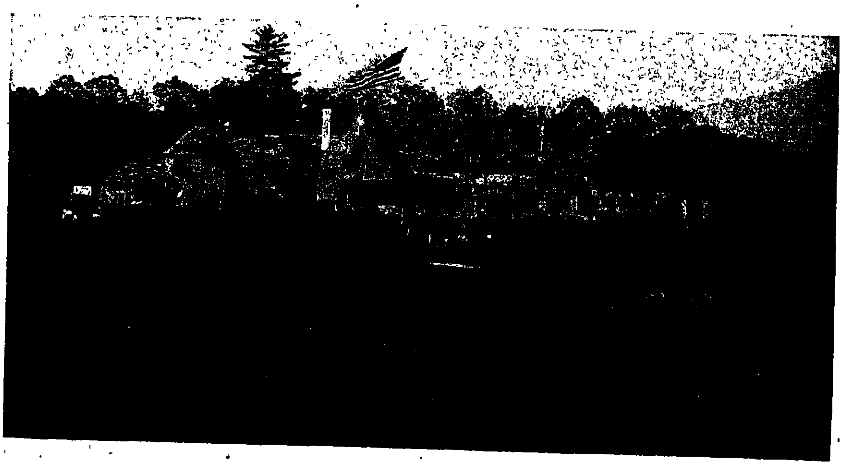
The annual Mershon Trophy competition in men's singles will be played, together with men's doubles, and if sufficient entries can be secured, ladies' singles and mixed doubles also.

The courts on which these games will be played will be announced later, but tennis players can be assured that excellent courts (probably clay) will be available for all who wish to use them.

Entries for all these events should be in the hands of the committee not later than Monday afternoon, June 22.

INSPECTION TRIPS

One of the three optional all-day trips scheduled for Friday, June 26, will be to the recently completed 25-acre plant of the American Enka Corporation the only Rayon plant in North Carolina. Inspection will be confined to the 4,400-kw. power plant and village only; the production units will not be open for inspection. The mill capacity is about 20,000



Biltmore Forest Country Club, Asheville, N. C., scene of the Mershon Trophy tournament June 22 and 24 lb. (75,000 miles) of viscose yarn per day.

Enka is about eight miles southwest of Asheville and, surrounded by the majestic mountains forming the southern extremity of the Appalachian range, is considered one of the beauty spots of western North Carolina. A water storage and settling basin has been constructed in the form of a picturesque 6,875-acre-ft. artificial lake on the borders of which three modern villages have been created for plant employees.

Invitations have been cordially extended by the State of South Carolina, the City of Columbia, and the Lexington Water Power Company to visit that state, its capital, and the 200,000-hp. Saluda River development near Columbia. The power company has offered to arrange for transportation from the railroad station to and from the dam where a barbecue will be given. Negotiations are pending with railway officials to run a special train from Asheville to Columbia at a reduced rate of fare.

If enough persons attending the convention evidence sufficient interest in this trip, arrangements will be completed for an all-day excursion Saturday, June 27.

North Eastern District Holds Busy Sessions at Rochester

BRINGING to a close for the current fiscal year the Institute's district meeting activities, engineers of the North Eastern District convened at the Sagamore Hotel in Rochester, N. Y., April 29-May 2. In addition to four regular technical sessions and a student convention there were held several special group meetings including a joint dinner meeting of national noise-study committees representing the National Electric Light Association, the National Electrical Manufacturers Association, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and other organizations.

Particularly noteworthy were the many entertainment features and inspection trips arranged by the local committees. Inspection trips included visits to the plants of such widely known organizations as the Eastman Kodak Company, Stromberg-Carlson Telephone Manufacturing Company, Bausch & Lomb Optical Company, General Railway Signal Company, in addition to stations of the Rochester Gas & Electric Company. The more diversive trips included drives through the city and a trip to Niagara Falls. A delightful series of special affairs kept women guests pleasurably active and should prove a future incentive for increasing feminine attendance at these meetings. Even the needs of golf and tennis enthusiasts were ably met.

Special credit is due to everyone assisting in the supply, installation, and operation of the public address system which was a most important contribution to the success of the technical sessions. Poor audibility in meeting rooms has killed the effectiveness of more than one otherwise good meeting. The ordinary installation of stationary microphones has failed to solve the difficulties which arise with a peripatetic speaker who spends a goodly portion of his time addressing the blackboard with his back toward his auditors. At Rochester the whole problem was admirably met with the newest thing in microphones, small units attached directly to the lapel of the speaker's coat thus removing the possibility of his walking away from the "mike." The Bell Telephone Laboratories, Inc., and the Stromberg-Carlson Telephone Manufacturing Company in collaboration installed and operated the equipment.

Two of the technical sessions were devoted to miscellaneous subjects ranging from insulation research to induction-motor design. One session was given over to an exceptionally well organized symposium on the subject of noise, covering its origin, measurement, and control. Several interesting and timely subjects crowded the student session, while the closing session dwelt upon the much-investigated but always popular subject of lightning and its related problems. Some of the "high spots" of the various papers are touched upon in the paragraphs which follow.

Power Cables and Dielectrics

In presenting his paper "Temperatures in Electric Power Cables Under Variable Loading," E. A. Church (A'29), Edison Electric Illuminating Company, Boston, emphasized the need of a practical and reasonably accurate method for making these calculations to improve cable operating efficiency. He gave a solution of the problem of determining the temperature rise from sheath surface to conductor, making use of Bessel functions and resolving the heat-flow cycle into its harmonics for separate solution as well as subsequent recombination in the proper phase relation to obtain the temperature cycle. The author stated that computations based upon his theory demonstrated that the temperature curve for any cable and load cycle may readily be calculated without excessive labor and with accuracies well within the necessities of cable constants.

Theories and calculations pertaining to the "Proximity Effect in Cable Sheaths" were presented by Prof. H. B. Dwight (F'26), Massachusetts Institute of Technology, Cambridge. He described proximity effect as being the unequal distribution of alternating current over the cross-section of a conductor as caused by current in another (parallel) conductor and stated that in some cases its calculation was of importance to prove its negligibility and in other cases to prove the importance of its consideration in connection with conductor design.

Assuming cable insulation to be essentially an imperfect condenser, Prof. C. L. Dawes (M'15) and W. M. Goodhue, both of Massachusetts Institute of Technology, Cambridge, presented a discussion of "Equivalent Circuits of Imperfect Condensers" as an aid to insulation studies and calculations.

"The Theory of Thermal Breakdown of Solid Dielectrics" as described by P. H. Moon (M'29), Massachusetts Institute of Technology, Cambridge, constituted a correlation of much of the work already done on the subject of thermal breakdown. It was the author's stated aim to present this information in a form in which it could be used by the electrical engineer for the calculation of breakdown voltage. He emphasized the fact that thermal effects are but one of several mechanisms of breakdown, and that in calculating breakdown voltage, due regard must be given to this fact.

Motors and Transformers

Some of the reasons why induction motors fail to develop their expected smooth speed-torque curves were described at length by P. H. Trickey (M'30), Westinghouse Electric & Manufacturing Company, East Springfield, Mass. He stated that present knowledge attributes the undesirable "hooks" or "cusps" in the speed-torque curves to three causes at least: (1) harmonics in the field, (2) synchronous lock-in of stator and rotor harmonics, and 3) the effect of stator slots. The first of these occupied the author's attention and it was his conclusion that harmonics in the field form have a definite effect upon the speed-torque curve; also that the assumption of each harmonic acting separately is useful (though approximate) in determining the speeds at which the worst cusps will occur.

In considering the determination of "Losses in Transformers for use with Mercury-Arc Rectifiers," E. V. DeBlieux (A'30), General Electric Company, Pittsfield, Mass., reviewed theoretical calculations previously published and discussed the assumptions involved. Methods proposed for an A. I. E. E. Standard also were described and a mathematical basis for them offered. Effort is being put forth to achieve a satisfactory method for determining rectifier transformer losses independent of rectifier losses.

"The Three-Circuit Transformer" was treated at length by C. F. Estwick (M'25), General Railway Signal Company, Rochester, N. Y. That class of transformer was described as being divided into two distinct types depending upon the relative directions of the fluxes in the mutual paths of the magnetic circuit. A typical problem for each case was cited and a mathematical analysis given.

Core-Loss Measurement

A method and apparatus for determining the core losses in magnetic sheet steels at high-flux densities were described by B. M. Smith (A'30) and C. Concordia (A'31), General Electric Company, Schenectady, N. Y. Modern demands require machines and equipment to be designed within narrowing limits and this necessitates more attention to the accurate determination of the characteristics of materials. The authors presented data in support of their contention that now it is possible to measure core losses for densities up to $B = 20{,}000$ conveniently and accurately, and that in order to obtain a true measure of "B max." it is not necessary to maintain a sine wave of induction.

Symposium on Noise

All seven of the papers presented at the noise session were liberally abstracted in the May 1931 issue of Electrical Engineering (pp. 340-354); hence they will be given no further attention here.

Student Session

President Lee (F'13) was introduced by Professor C. W. Henderson (A'20), chairman of the district committee on student activities, and emphasized very forcefully the benefits received by students who attend and participate in such meetings, stating that otherwise the contacts thus made with men and the electrical industry might not be made for months or years. He urged the young men to learn to speak and write clearly and concisely, as the presentation of reports would constitute a very important part of their engineering work.

Technical papers presented by students are outlined in the following paragraphs:

"The Theory of the Capacitance Potentiometer" as presented by A. W. Moon and W. E. Brainard, Cornell University, Ithaca, N. Y., deduced relations for the characteristics of a transformer circuit which would be suitable for use for connection across a portion of a string of high-voltage insulators. Such a connection is used now for certain instrument circuits where the cost of high-voltage instrument transformers is unwarranted; it was suggested for other possible light-load uses including radio beacons.

As a result of "Tests on 14-Megacycle Antenna Systems" reported upon by C. B. Evans, University of New Hampshire, Durham, the author stated that from experiment it appears that the most suitable radiator for 14-megacycle general amateur radio communication is a horizontal half-wavelength Hertz antenna placed as high as possible and fed as easily and as efficiently as possible. His results showed also that although antenna operation on the second harmonic is satisfactory, operation on the fundamental frequency is better.

In describing methods of "Revision of Distribution Transformer Networks," L.O. Spencer, University of Maine, Bangor, emphasized the economic desirability of building up a system of distribution maps and records, and equipment records, particularly on the older systems and where small communities and rural areas predominate. He based his comments upon experience with a northeastern electric service company whose lines and services were severely damaged by an unusually severe sleet storm in 1929, the replacement and reconstruction of these lines being rendered extremely difficult by a lack of adequate line and equipment records.

In a "Study of the Torque-Time and Slip-Time Relation of an Induction-Motor Flywheel Set Operating on a Mine Hoist," D. C. Robinson and R. W. Stone, Syracuse (N. Y.) University, attempted to solve some of the problems of industrial-motor applications where energy demands vary over a wide range within one cycle of operation. The authors presented fairly extensive experimental results together with mathematical and graphical analyses.

Possibilities surrounding "The Piezoelectric Oscillator in the Power Industry" were described by B. H. Buckingham, Massachusetts Institute of Technology, Cambridge. Super-synchronous operation of widely separated power systems through Piezo oscillator frequency control was suggested as a possibility at sometime in the future, assuming that the crystalline structure already successfully applied to the synchronization of two or more radio broadcast stations could be developed to meet the relatively rigorous demands of power-system regulation.

"A Modern Short-Wave Amateur Transmitter," recently built by the Yale Radio Club, was described by Donald Bergener of Yale University, New Haven, Conn. The set was designed and built with particular attention to high-efficiency and stable-frequency operations in the three amateur channels, 3,500-4,000 kc., 7,000-7,300 kc., and 14,000-14,400 kc. The circuit used is the tuned-plate untuned-grid type, with a power amplifier of the class-C type, using two of the '52-type tubes. A power supply common to both oscillator and amplifier is fed from a three-phase bank of 220/2,000-volt transformers through a mercury-vapor rectifier and "brute-force" filter. In operation both the amplifier and oscillator are keyed simultaneously by changing the grid bias, thus effectively eliminating noticeable key clicks. Highly successful intercontinental communication with the set was reported.

In their "Study of the Fynn-Weichsel Motor," G. S. Brown and J. C. Gibson, Massachusetts Institute of Technology, Cambridge, presented an analytical description of that motor and its operating characteristics in the direction of power-factor correction. The authors stated that in their opinion the power-factor corrective ability of the motor is in certain cases a valuable asset, but recommended careful consideration of the local conditions in connection with each individual projected application.

Under the title "Starting Windings" P. H. Trickey, University of Maine, Bangor, presented a short-cut method of designing the auxiliary starting windings of split-phase induction motors. He based his findings and mathematical analyses upon practical design experience.

Session on Lightning

Seven papers presented by thirteen authors dealing with various phases of the lightning problems were given at the lightning session. These papers in general fell into three classifications: (1) theory, evolution, and laboratory development; (2) studies of the effects of natural lightning on operating systems; and (3) studies based upon the imposition of artificial lightning surges upon operating systems. The paper "Characteristics of Lightning . . ." presented by F. W. Peek, Jr. (F'25), General Electric Company, Pittsfield, Mass., was devoted to showing how the various characteristics of lightning may be obtained from measurements on operating lines and how such results may be applied advantageously in developing line designs. The author stressed particularly the fact that oscillograms of traveling waves give a "remarkably complete and easily read story of the life and characteristics of the lightning which produces them." From these observed data the author described methods of determining cloud height, time of discharge, induced voltages, and current.

In discussing "Lightning Discharges and Line Protective Measures," C. L. Fortescue (A'23), Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa., and R. N. Conwell (A'15), Public Service Electric & Gas Company, Newark, N. J., described the mechanics of the development of a lightning stroke in a cloud and the formation of a surge on a line. Analyses of typical high-voltage line construction were presented to show the lightning performance obtained, and 220-kv. operating experience records were offered to substantiate the belief that induced surges are of relatively small importance; also that the direct stroke is the criterion for good design.

"Experimental Studies in the Propagation of Lightning Surges on Transmission Lines," were described by O. Brune and J. R. Eaton (A'27), Consumers Power Company, West Jackson, Mich. The authors presented reproductions of cathode-ray oscillograms to show the attenuation and distortion of artificial lightning surges on a power transmission line, the voltages induced by such surges in parallel wires, and the effect on tower-footing impedance of ground wires or counterpoises.

Lightning Experiences

Four of the papers presented were based upon data obtained from operating systems under natural lightning conditions.

Edgar Bell (A'29) and A. L. Price (A'30), Pennsylvania Power & Light Company, Hazelton, Pa., described the results obtained from the continuation of their "Lightning Investigation on the 220-Kv. System of the Pennsylvania Power & Light Company (1930)." Lightning instruments in service on this system include some 300 lightning-stroke recorders, more than a thousand surge indicators, 39 surge-voltage recorders, two cathode-ray oscillographs, three field-intensity recorders, four lightning-severity meters, in addition to magnetic oscillographs and high-speed recording ammeters at terminal stations. These authors are convinced that at least a large proportion of the lightning kick-outs on their 220-kv. system are caused by direct strokes to line structures or conductors.

Philip Sporn (F'30), American Gas & Electric Company, New York, and W. L. Lloyd, Jr. (M'27), General Electric Company, Pittsfield, Mass., presented data from the "1930 Lightning Investigations on the Transmission System of the American Gas & Electric Company." These authors reported that of 107 surges recorded on the system in Ohio, 33 per cent were caused by lightning, and 60 per cent by switching. Of the surges caused by lightning 85 per cent were positive or predominantly positive, and 8.5 per cent were purely negative (a ratio of ten-to-one). Of the surges caused by lightning, half were oscillatory and half were not. Of the oscillatory group, half were positive and half were negative.

W. W. Lewis (M'13) and C. M. Foust (A'22), General Electric Company, Schenectady, in "Lightning Investigation on Transmission Lines—II," reviewed the results of a five-year investigation of the effect of lightning on transmission systems. The authors concluded that direct strokes play a prominent part in causing flashovers, but admitted that induced strokes also seem important. These authors contended that conventional overhead ground wires with low tower-footing resistance take care of direct strokes as well as induced strokes, and operate to prevent flashovers. They also reflected and emphasized the opinion that the mechanism of a lightning stroke as yet is not understood, but that polarity effects are indicated to be of a highly important nature and worthy of careful consideration in line design.

I. W. Gross (A'12), American Gas & Electric Company, New York, and J. H. Cox (A'25), Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., described the "Lightning Investigation on the Appalachian Electric Power Company's Transmission System." One of the characteristics of the system in question is the fact that tower-footing resistances almost universally are high, 250-ohms or more in many cases. Special equipment installed on that system at the present time includes 21 klydonographs, one cathode-ray oscillograph, and 35 direct-stroke recorders.

Inter-Society Cooperation Urged to Expedite Noise-Study Agreement

THAT the Institute should officially recognize the importance of the several angles of the noise-study situation by appointing qualified representatives to cooperate actively with corresponding groups in other societies was the concensus of opinion of the Institute members in attendance at a joint dinner meeting held at Rochester, N. Y., May 1, 1931. The dinner meeting presided over by P. L. Alger (F '30) chairman of the A. I. E. E. committee on electrical machinery and an aggressive leader in noise-study activities, closed a day devoted to the presentation and discussion of seven papers and the demonstration of four different types of noise-measuring instruments. Specialists and various committee members contributed to the dinner discussion which was centered upon an attempt at selection of definite units and methods of measurement and evaluation of noise. Without a common language for these essentials no cooperative progress can be made.

These topics have been under consideration for some time by committees of the N. E. M. A., A. S. M. E., and the Acoustical Society of America, and representatives of all these groups participated in the discussion. While no definite agreement could be reached, three principal questions were crystallized, the answers to which form a fairly complete basis for a system of noise measurement:

1. How shall the unit of noise measurement be defined?
2. What is a suitable scale of values for noise that will cover the wide range of noise intensities met with in practise?
3. What weighting factors shall be used to correlate the noises produced by sounds of different frequencies?

The accompanying table listing the characteristics of eight different proposed noise measurement systems indicates the ways in which these questions have been answered by different investigators. The conclusions of the Rochester meeting are summarized in the following paragraphs by Mr. Alger.

I—The Unit of Noise Measurement

Since all noise is the result of waves of sound pressure, it is logical to measure it in terms of dynes per square centimeter pressure to which the name "equivalent bars" might be given. Such a measurement being based wholly upon mechanical pressure will avoid many of the difficulties involved in a measure primarily based upon psychological effects which would necessarily change as more data are obtained. However, as tones of different frequencies are not equally audible, it is desirable to convert all measurements into equivalent sound pressure at a definite standard frequency. On this basis, the consensus of opinion was that:

Noise should be measured in equivalent bars of the sound pressure produced by a pure tone of frequency 1,000 cycles per second.

VARIOUS NOISE SCALES PUBLISHED OR PROPOSED UP TO APRIL, 1931

Name	1 Pressure dynes cm.^{2}	2 Intensity	3 Sensation level loudness	4 Noise level	5 Sound level	6	7 Masking	8 Deafening
Scale........	Linear....	Db.	Db........	Db.......	Db.	Db.	Db....	Arbitrary
Ref. pt., dynes cm.^{2}	0	6.5	Thshld.	Thshld.	0.001	0.01	Thshld.	Thshld.
Frequency		1,000	700	Street noise	1,000	1,000	Warble	Buzz
Weighted	No	Yes	Yes	Yes	Yes	Yes	Uses ear	Uses ear
			Examples					
Just painful	2,500	50	130	130	125	105	115	100
Just audibl	0.0005	−80	0	0	−5	−25	0	0
Average residence	0.05	−45	32	35	30	10	20	20

Db. = decibel. Thshld = threshold. One decibel = 12 per cent change in sound pressure.

II—THE SCALE OF NOISE MEASUREMENT VALUES

As the range of audible sound pressure varies from 0.0005 to 2,500 equivalent bars a definition of noise in terms of pressure alone does not give a satisfactory impression of its magnitude. The logarithm of the sound pressure corresponds roughly to the sensation experienced, and this quantity is also very convenient for describing the sound transmission qualities of materials. For these reasons it was the consensus of opinion that:

> While noise may properly be expressed in equivalent bars (or milli-bars or kilo-bars), it is also desirable to express it on a logarithmic scale or in decibels where the difference in decibels between two pressures P_1 and P_0 is given by 20 log P_1/P_0. The zero of the decibel scale (P_0) should be taken at a convenient reference point such as 0.001 or 0.01 bars at 1,000 cycles. That is, one decibel is defined as a change in equivalent sound pressure of 12 per cent.

There was some feeling that the reference level should be taken as the threshold of audibility but the uncertainty of this level and the probability that it will change in future as more precise knowledge is gained led the majority to prefer the absolute level mentioned above.

III—FREQUENCY-WEIGHTING FACTORS

Since the audibility of sounds of different frequencies varies from zero for frequencies below about 20 cycles per sec. through a maximum at about 2,000 and down again to zero at about 20,000 cycles per sec., it is necessary to multiply the actual sound pressures by weighting factors to reduce them to a common basis. Also, since the relative audibilities of different sound frequencies vary greatly with the noise intensity, it is necessary to use different weighting factors for different levels of noise. It does not seem practical at present to have a uniformly varying weighting factor scale incorporated in a noise-measuring device, so that it seems best to establish several different weighting-factor curves for use in different zones of noise. It was the consensus of opinion, therefore, that:

> Approximately three distinct frequency-weighting-factor curves should be agreed upon, on the basis of average experimental results with a series of observers, for use in noise zones of approximately 0-20, 20-50, and above 50 db.

All noise measuring instruments should then be equipped with three networks, giving these multiplying factors for different frequencies, and all measured results should be accompanied by a statement of the network used.

IV—ADDITIONAL QUESTIONS

Questions requiring further discussion, although their solutions do not seem necessary for immediate progress, are:

4. How shall allowance be made for the fact that all noise-measuring instruments so far known record the r. m. s. value of the weighted sound pressures, whereas the ear gives more weight to the notes of higher intensity, and to certain disagreeable combinations of them?

5. How shall allowance be made in commercial measurements for reflections from walls and other objects near the source of sound?

6. How shall allowance be made for the fact that low-frequency noises are more easily transmitted through structures than high-frequency noises, so that the relative sound pressures of different frequencies vary with the distance from the source?

7. How shall the commercially acceptable noise levels for different types of apparatus and different locations be defined?

It is believed that agreement on the three principal questions can be reached in a reasonable period through joint action of the committees of the several interested engineering societies. The Bureau of Standards and other laboratories have agreed to accept any conclusions reached by these engineering committees; hence responsibility rests upon the engineering societies for bringing this matter to conclusion.

District Executive Committee Meets at Rochester, N. Y.

The executive committee of District No. 1 held a luncheon meeting on Thursday, April 30, during the District meeting in Rochester. In the absence of Vice-President I. E. Moultrop (F '29), Wellen H. Colburn (M '26) served as temporary chairman.

A. C. Stevens (M '26), secretary-treasurer of the District, presented a detailed statement of receipts and expenditures since the October meeting of the committee, and H. J. Klumb (A '16), chairman of the local executive committee for the Rochester meeting, supplied information regarding some of the expenses incurred in that connection.

It was announced that the board of directors had approved the holding of a District meeting in Providence early in May of 1932, and, after a discussion regarding the most desirable time, the dates of May 4-7 were chosen to be recommended to the executive committee for 1931-32.

Student Activities Conference Held at Rochester

The North Eastern District's annual conference on student activities was held as a luncheon meeting on Friday, May 1, with Prof. C. W. Henderson (A '20), counselor Syracuse University Branch and chairman of the District committee on student activities, presiding. Nine of the thirteen Branches in the District were represented by their counselors and chairmen; one was represented by the counselor only. Prof. Henderson was re-elected chairman of the District committee on student activities; Prof. C. L. Dawes (M '15), counselor of Harvard University Branch, and Prof. W. B. Hall, (M '28), counselor of Yale University Branch, were elected to serve with him on the executive committee of the District committee.

Professor F. M. Sebast, (M '27), counselor of the Rensselaer Polytechnic Institute Branch, and past-chairman of the District committee on student activities, presented a comprehensive report upon the types of technical papers presented in the past by students in the District, and discussed some of the factors involved in efforts to encourage all Branches to submit papers for the annual meeting.

Henry H. Henline (M '26), assistant national secretary, gave a brief summary of the types of student papers presented in such sessions in other Districts, and the subjects discussed at their conferences.

In the discussion that followed, the principal topics mentioned were (1) the desirability of active student participation in the Branches, (2) importance of interesting sophomores and juniors, (3) contacts with Sections, (4) methods of getting more of the practising engineers to attend student sessions, and (5) the importance of visits to the Branches by national officers.

Prof. W. H. Timbie (F '24), counselor of the Massachusetts Institute of Technology Branch, and chairman of the A.I.E.E. committee on student Branches, spoke briefly of the great need among high school students for accurate information on electrical engineering, and mentioned the plans of his committee to supply it.

President Lee spoke briefly upon the importance of the student activities, and mentioned the provision for allowing traveling expenses to the vice-presidents for visits to the Branches in their districts.

A Summary of Some Rochester Discussions

ONLY discussion given at the meeting and submitted in writing in accordance with governing A. I. E. E. rules is summarized; complete discussion, together with all papers so approved, will be published in the TRANSACTIONS. The titles of the papers and the names of their respective authors were published in ELECTRICAL ENGINEERING, April 1931, page 302.

ELECTRIC POWER CABLES

F. L. Buller's discussion of "Temperatures in Electric Power Cables Under Variable Loading" was read by P. L. Alger. It called attention to the statement on page six of the paper where the heat storage capacity of the lead sheath was neglected. He pointed out that in large cables the thermal capacity of the sheath was often equal to 80 per cent of that of the conductor and 25 per cent of that of the cable as a whole and for other types of cable it might even be of a larger percentage. He suggested that the equations in the paper should be analyzed to determine the effect of the omission of this factor on the results.

R. W. Atkinson discussed "Proximity Effect in Cable Sheaths" particularly formula (7) of the paper which related to sheath losses in three-conductor cables. He analyzed this formula transforming it into a convenient form of application and presented an approximate sheath-loss formula for three-conductor cables which gave values for sheath loss but from 2 per cent to 5 per cent higher than that obtained from formula (7) in the paper.

MOTORS—TRANSFORMERS

C. G. Veinott discussed "Cusps in the Speed-Torque Curves of Induction Motors." He believed that quantitatively it would be more accurate to assume the harmonic motors excited by constant primary current rather than by constant primary voltage.

G. Camilli discussed "Core Loss Measurements at High-Flux Densities" and believed it would have been of great value had data been given to show just what errors would have occurred had the older methods of measurement been used.

MAGNETIC NOISE IN SYNCHRONOUS MACHINES

H. D. Taylor discussed this subject and explained that the theory described by the authors which accounted for tooth-frequency noise was very similar to one developed by his associates and confirmed by several years' experience in designing and testing low-speed synchronous machines. Mr. Taylor's experience also confirmed the authors' statement that the worst cases of noise are likely to be associated with pole-and-slot combinations giving nearly an integral number of slots per pole. His experience with respect to the frequency of noise differed from the authors' rule. Analysis indicated that it should be a multiple of twice the line-voltage frequency times the integer nearest to the number of slots per pole.

C. E. Kilbourne discussed this subject also and explained that from a number of observations on machines having several types of rotors he had never found a case where noise could be directly traced to the rotor. Stethoscopic analysis of the stator itself indicated an increase in the volume of noise from that stator core. Another valuable part of his discussion analyzed the general equation of A. L. Ruiz for the vibration of a homogeneous ring which when there are a large number of nodes with an increased frequency is more accurate of application to this problem than is Timoshenko's equation.

MACHINERY NOISE IN BUILDINGS

J. A. Jackson discussed this subject and explained that a much closer cooperation between the electrical industry, the architects, and the consulting engineers would be needed to solve completely the noise troubles which arise in buildings. With a tendency to reduce building cost resulting in a lighter type of construction, this problem within the past few years has become increasingly difficult. Thinner walls, floors and ceilings vibrate more readily and act as sounding boards.

LIGHTNING

F. E. Andrews discussed this subject and gave data obtained by the performance of 132-kv. lines which substantiated the value of ground wires for preventing

Floodlighting at Sea

TOWERING 128 ft. above the water line, the floodlighted funnels of the new 758-ft., 42,500-ton Canadian Pacific liner "Empress of Britain" are expected to be visible for 30 miles.

interruptions. Lines of double-circuit steel-tower construction with only a single ground wire over single-circuit portions of these lines had on the average 3.78 interruptions per 100 mi. per year while parts of these lines which had double circuits with a ground wire above each circuit had only an average of 1.10 interruptions per 100 circuit miles per year.

L. V. Bewley discussed Mr. Peek's paper "Lightning" and explained that by tying down into a single set of curves (Fig. 6) the seven main factors which characterize the magnitude and shape of induced-voltage waves due to a lightning discharge; it constituted an outstanding contribution to the present knowledge of magnitudes of induced strokes. By mathematical demonstration he illustrated the application of these equations in the Appendix of Mr. Peek's paper to a specific case.

LIGHTNING VS. LINE PROTECTION

K. B. McEachron discussed "Lightning Discharges and Line Protective Measures" and in connection with the authors' versions of the mechanism of lightning strokes he believed it would be helpful if the authors could give a more detailed explanation of just what they believed happened during the interval just before and after lightning strikes. Another point in his discussion referred to the separations between line and ground wires as shown in Figs. 3 and 4 of the paper; these he believed were unnecessarily large since many lines similar to that shown in Fig. 4 but with much smaller clearances between line and ground wires and low tower-footing resistance have had excellent operating records.

J. J. Torok's discussion of "Lightning Discharges and Line Protective Measures" was read by J. H. Cox. To supplement the general treatise of the paper the results of calculations of the effects of the tower on the reflections of traveling waves were illustrated with lantern slides. Mr. Torok also explained that the analysis and accompanying curves as presented in the paper were of considerable importance as they give for the first time a clear insight into the happenings on a transmission line at the time it is struck.

EXPERIMENTAL LIGHTNING STUDIES

L. V. Bewley discussed "Experimental Studies in the Propagation of Lightning Surges on Transmission Lines" with particular references to the authors' conclusions about the counterpoise. He presented data from tests and equations which substantiated his belief that the major benefit to be derived from the use of a counterpoise was a reduction in true grounding resistance, and that the surge impedance and reflections are quite subsidiary effects. These results indicate that a given length of wire is most efficiently employed as a counterpoise by using it as a number of short lengths in parallel radiating out from the tower rather than as a single length. The direction of the counterpoise it was thought has no particular virtue.

J. H. Cox discussed "Lightning Investigations on Transmission Lines—II." He believed that these data were gratifying as they indicated the benefits derived from the use of a ground wire. He commended also the results contained in Table I on the use of buried cable to reduce tower-footing resistance. On the other hand he cited reasons why he did not agree with the authors that a direct stroke to a line conductor would provide necessarily sufficient voltage for insulation breakdown.

DO STREAMERS BUILD UP OR DOWN?

K. B. McEachron discussed the mechanism of the lightning stroke and the probability of discharges proceeding from the tower to the cloud when the cloud is negative. In the light of present evidence he believed that in order to obtain definite evidence from which to build up an adequate theory further study should be given to the determination of the manner of propagation of discharges.

1931 Lamme Medal Nominations Must be Made by October 1

Special attention is directed to the fact that the names of Institute members who are considered eligible candidates for the Lamme Medal to be awarded in the Fall of 1931 may be submitted by any member in accordance with Section I of Article VI of the By-laws of the Lamme Medal Committee, as quoted in the following:

> The committee shall cause to be published in one or more issues of the A. I. E. E. JOURNAL each year, preferably including the June issue, a statement regarding the "Lamme Medal" and an invitation for any member to present to the national secretary of the Institute by October 1 the name of a member as a candidate for the medal, accompanied by a statement of his "meritorious achievement" and the names of at least three engineers of standing who are familiar with the achievement.

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, to enable the committee to determine its significance as compared with other candidates'. If the work of the nominee has been of a somewhat general character in cooperation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified above.

The Lamme Medal, founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Mfg. Company (deceased July 8, 1924), provides for the annual award by the Institute of a gold medal—together with bronze replica thereof—to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery;" for the award of two such medals in some years if the accumulation of funds warrants.

The third (1930) Lamme Medal has been awarded to Dr. William James Foster (F '16) consulting engineer, (retired), General Electric Company, Schenectady, N. Y., "for his contributions to the design of rotating a-c. machinery;" presentation to be made during the summer convention at Asheville, N. C., June 22-26, 1931.

Edison Bust Unveiled in German Hall of Fame

Dedicated to the "spirit of indomitable research" the remarkable likeness of Thomas Alva Edison sculptured by Mrs. Evelyn Longman Batchelder was unveiled in the Hall of Honor of the Deutsches Museum, Munich, Thursday, May 7, 1931. Sponsored jointly by the Edison Pioneers and the American Institute of Electrical Engineers, this marble bust (see ELECTRICAL ENGINEERING, Jan. 1931, p. 59), was bestowed upon the museum at the time of its annual meeting presentation being made by H. H. Barnes, Jr., chairman of the joint committee of sponsors, and on behalf of the electrical engineers of America. Response to the presentation address was given by his excellency Dr. Oscar von Millar, the genius to whom credit is due for the creation of the museum and its development to the present imposing proportions. Dr. von Millar paid tribute to Mr. Edison "as a world figure and as a benefactor of humanity."

Dr. H. Schacht, chairman of the board of directors of the museum, former president of the Reichsbank, and spokesman for German interests during the drafting of the Young Plan, presided over a group of some 400 statesmen, scientists, and industrial leaders from all over Germany.

The Deutsches Museum has arranged five rooms in its electrotechnical division, one the Hall of Honor and the others devoted respectively to historic exhibits of transformers, storage batteries, transmission materials, and the industry in general. In the Hall of Honor there is installed the first dynamo made by Werner von Siemens along with other early models of dynamos. The Edison bust is one of two accorded a position in the Hall; the other is that of von Siemens. On the pedestal of the Edison bust is inscribed:

> The great inventor to whom the world is indebted for pioneering advances in the most varied fields of scientific and engineering endeavor.

On the pedestal of the von Siemens bust there is the inscription:

> The distinguished scientist and engineer whose work created the foundation of electrotechnics.

The personnel of the joint committee which handled all details for the A. I. E. E. and the Edison Pioneers included as representatives of the Institute, H. H. Barnes, Jr. (F '13), vice-president, General Electric Company, chairman; H. P. Charlesworth (F '28), vice-president, Bell Telephone Laboratories, Inc., and a vice-president A. I. E. E.; K. G. Frank, (M '14), consulting engineer of New York; and C. E. Stephens (M '22), vice-president and northeastern district manager of the Westinghouse Electric & Manufacturing Company and a director of the A. I. E. E. John W. Lieb (deceased) was the first chairman of the joint committee. Representing the Edison Pioneers were Edward D. Adams (A '10), deceased; W. S. Barstow (F '12—Life Member), president, W. S. Barstow & Co., N. Y.; G. F. Morrison, honorary vice-president of the General Electric Company; and W. H. Meadowcroft, of the Edison Laboratories.

Lighting Pioneer Dies on Pacific Coast

Augustus D. Curtis, president and founder of Curtis Lighting, Inc., died suddenly April 29, 1931, at Beverly Hills, California, at the age of 65.

His passing culminates a life devoted to the art and science of illumination, his major contribution being the active promotion of indirect lighting and the foundation of a company dedicated to the advancement of lighting. Mr. Curtis was born at Hawley, Pa., October 14, 1865, the son of a country physician.

A. I. E. E. Directors Meet in New York

THE regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, Tuesday, May 19, 1931. Present were: *president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—W. S. Rodman, Charlottesville, Va.; C. E. Sisson, Toronto, Ont.; G. C. Shaad, Lawrence, Kans.; H. P. Charlesworth, New York, N. Y. *Directors*—E. B. Meyer, Newark, N. J.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, A. E. Knowlton, R. H. Tapscott, New York, N. Y.; A. B. Cooper, Toronto, Ont. *National treasurer*—W. I. Slichter, New York, N. Y. *National secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of March 12, 1931, were approved. The board ratified its executive committee's action of April 3, 1931, in enrolling 66 Students; electing 128 Associates, 6 Members, and 1 Fellow; transferring 15 to Member grade and 5 to Fellow grade.

Reports of board of examiners' meetings of March 25 and April 29 were presented and approved. Upon the recommendation of the board of examiners, 138 Students were enrolled; 87 Associates were elected; 6 Members were elected; 6 applicants were transferred to the grade of Member.

Approval by the finance committee, for payment, of monthly bills amounting to $30,268.77, was ratified.

The national secretary reported 1,805 members in arrears for dues for the fiscal year which ended April 30, 1931, and was directed to transfer their names from the mailing list (after the distribution of the June and July issues of ELECTRICAL ENGINEERING) to a "suspended" list, and to employ the usual methods of collecting these dues and restoring the members to the active membership list.

The annual report of the board of directors to the membership for the fiscal year which ended April 30, 1931, as prepared under the direction of the national secretary, was considered and approved for presentation at the annual meeting of the Institute at Asheville, N. C., June 22.

The national treasurer presented a report covering the fiscal year just closed. Annual reports of the general standing committees (exclusive of the reports of the technical committees, which will be presented at the summer convention in June) were received. Abstracts of these reports were incorporated in the board of directors' annual report.

The national secretary submitted a report relating to several proposed Institute activities and upon his recommendation the president was authorized to appoint a special committee to study and report upon present and proposed Institute policies.

Authorization was given to the meetings and papers committee to schedule two papers by non-members for the summer convention.

The report of the committee on award of Institute prizes, of the awards made covering the year 1930, was presented and accepted.

Upon the recommendation of the standards committee, (1) approval was given to a minor revision of A. I. E. E. Standard No. 26 on "Automatic Stations," made by the committee on automatic stations; (2) approved for presentation to the American Standards Association for consideration as an American Standard, "Symbols for Mechanics, Structural Engineering, and Testing Materials," prepared by the sectional committee on scientific and engineering symbols and abbreviations. As a member-body of the American Standards Association, the Institute's approval was given to proposed revisions of the constitution of that organization.

A report was presented of a special committee appointed upon the recommendation of the delegates' conference at the 1930 summer convention, to consider membership grades in the Institute (below that of Member), entrance and transfer fees, etc. This report, in effect, recommended that no change be made at this time in the present arrangement of including all members below the grade of Member in the single grade of Associate, and that the entrance and transfer fees now in force be continued. Report approved.

In accordance with Section 37 of the Institute's constitution, consideration was given to the appointment of a national secretary for the administrative year beginning August 1, 1931. F. L. Hutchinson, present national secretary, was reappointed, and a resolution was adopted expressing the board's appreciation of the value of his services.

As a result of a communication from the Polish Association of Electrical Engineers, suggesting cooperation, the secretary was authorized to make arrangements with that organization for the exchange of membership privileges for visiting members, similar to the arrangements in force with several other foreign engineering societies.

An invitation to send delegates to the Fourth Pan American Commercial Conference, in Washington, October 5-12, 1931, was accepted and the president was empowered to appoint the delegates.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

Who Received The First E. E. Degree?

Recent efforts upon the part of Institute headquarters to answer the question as to what American college was the first to award a degree in electrical engineering resulted in the collection of the following interesting information:

The Tufts College catalogue for 1882-83 contained an announcement of a course in electrical engineering arranged in connection with other departments of instruction extending over a period of three years and leading to a special degree.

In June 1883, F. S. Pearson received a degree in civil engineering at Tufts College, and in 1885 he was awarded a new diploma containing recognition of the fact that he had completed the course in electrical engineering. Thus, while the use of the expression "electrical engineering" in connection with a degree was first used at Tufts College in 1885, it was made retroactive by the issuing of a new diploma.

Lehigh University announced in its catalogue for 1883-84 a special advanced course in electrical engineering requiring one year for completion. The first class entered in the fall of 1884 and completed the work in June 1885, receiving certificates but not degrees. The first degrees in electrical engineering at this university were awarded in 1891.

The Massachusetts Institute of Technology announced August 1, 1882, the establishment of a four-year curriculum in electrical engineering under the administration of the department of physics, beginning with the opening of the academic year 1882-83. Two degrees for completion of this curriculum were awarded in 1885.

The Cornell University curriculum in electrical engineering was established early in 1883 as an offshoot of the department of physics, and the first degrees were awarded in 1885.

Additional information regarding early degrees in electrical engineering will be deeply appreciated by the Institute headquarters staff. Address correspondence to Henry H. Henline, assistant national secretary, A. I. E. E., 33 West 39th St., New York, N. Y.

Institute Priz Awards Announced for 1930 Papers

FOUR national prizes for papers submitted during the calendar year 1930 have been announced by the committee on award of Institute prizes, which committee consists of A. E. Knowlton (F '30) chairman, L. W. Chubb (F '21) and W. S. Gorsuch (M '17). These prizes in each case consist of $100 in cash and suitable certificates; in cases of joint authorship the cash to be divided. Personal presentation of the prizes will take place at the first session of the Institute's summer convention at Asheville, N. C., June 22-26, 1931.

District prizes as announced by five Districts include ten awards of $25 each together with appropriate certificates. As in the case of the national prizes, where there is a joint authorship the cash awards are divided.

NATIONAL PRIZES

First prize for theory and research, awarded jointly to R. H. Park (A '27) and W. F. Skeats (A '27) for their paper "Circuit-Breaker Recovery Voltages" presented at the Middle Eastern District meeting, Philadelphia, Pa., October 13-15, 1930.

First prize for engineering practise, awarded to V. M. Montsinger (F '29) for his paper "Loading Transformers by Temperature" presented at the winter convention, New York, January 27-31, 1930.

Honorable mention was made of the paper by W. B. Kirke (A '19), "The Calculation of Cable Temperatures in Subway Ducts" presented at the North Eastern District meeting, Springfield, Mass., May 7-10, 1930.

No prize was awarded in the field of public relations and education.

NATIONAL PRIZE FOR INITIAL PAPER

Initial-paper prize awarded jointly to E. E. George (M '29) and R. H. Bennett, Jr., (A '25) for their paper "Directional Ground Relays" presented at the summer convention, Toronto, Ont., June 23-27, 1930.

Honorable mention given to E. T. J. Brandon (F '20) for his paper "The 220,000-Volt System of the Hydro-Electric Power Commission of Ontario" presented at the summer convention, Toronto, June 23-27.

NATIONAL PRIZE FOR BRANCH PAPER

Branch-paper prize awarded jointly to J. R. Outt and E. H. Pemberton for their paper "Neutral Grounding Reactors for Power Systems" presented at a joint meeting of the University of Colorado Branch and the Denver Section, May 24, 1930.

Honorable mention made of the paper by G. W. Barnes "A Vacuum-Tube Wattmeter" presented at a meeting of the Oregon State College Branch, May 24, 1930.

DISTRICT PRIZES

District No. 1

First prize awarded to J. E. Clem (M '30) for his paper "Arcing Grounds and Effect of Neutral Grounding Impedance" presented at the North Eastern District meeting, Springfield, Mass., May 7-10, 1930.

Initial-paper prize awarded to F. R. Longley (A '25) for his paper "The Calculation of Alternator Swing Curves" presented at the North Eastern District meeting, Springfield, Mass., May 7-10, 1930.

Branch-paper prize awarded to F. K. Fischer for his paper "Magnetic and Electrical Properties of Some Chromium-Steel Alloys" presented at the student Branch convention, Springfield, Mass., May 9, 1930.

District No. 6

Branch-paper prize awarded jointly to J. R. Outt and E. H. Pemberton for their paper "Neutral Grounding Reactors for Power Systems" presented at a joint meeting of the University of Colorado Branch and the Denver Section, April 18, 1930.

District No. 8

First prize awarded jointly to F. E. Terman (A '13), D. E. Chambers (A '30), and E. H. Fisher (A '30) for their paper "Harmonic Generation by Means of Grid-Circuit Distortion" presented at the Pacific Coast convention at Portland, Ore., September 2-5, 1930.

Honorable mention was made of a paper by E. R. Stauffacher (M '26) "Development of a Relay Protective System on the Lines of the Southern California Edison Company, Ltd." presented at the Pacific Coast convention, Portland, Ore., September 2-5, 1930.

District No. 9

First prize awarded jointly to F. O. McMillan (M '26) and E. O. Starr (M '29) for their paper "The Influence of Polarity on High-Voltage Discharges" presented at the Pacific Coast convention, Portland, Ore., September 2-5, 1930.

Initial-paper prize awarded to E. O. Goodale (A '27) for his paper "Errors in Power Metering" presented at a meeting of the Seattle Section, May 20, 1930.

Branch-paper prize awarded to Lowell Hollingsworth for his paper "A Visual Lichtenberg Figure Voltmeter" presented at a meeting of the Oregon State College Branch, May 24, 1930, and at the Pacific Coast convention, Portland, Oregon, September 2-5, 1930.

Honorable mention was made of a paper by H. D. Garrison and L. E. Steele, "The Development of a Tesla Coil," presented at a joint meeting of the Seattle Section and University of Washington Branch, April 15, 1930.

District No. 10

First-prize awarded to T. R. Rosebrugh (A '91) for his paper "The Analytics of Transmission Calculations" presented at the summer convention, Toronto, Ont., June 23-27, 1930.

Initial-paper prize awarded to T. R. Rosebrugh for his paper "The Analytics of Transmission Calculations" presented at the summer convention, Toronto, Ont., June 23-27, 1930.

V. D. I. Celebrates Its 74th Anniversary

On May 12, celebrating the seventy-fourth year of its existence, the Verein Deutscher Ingenieure unveiled at Alexisbad, Germany, a statue as a memorial to its founders and their aim "to coordinate the efforts of the best technical brains for the benefit of the whole industry of the country." Today the V. D. I. has 31,000 members in 53 districts and 29 local branches in Germany besides three foreign branch societies, one each in China, Argentina, and Japan.

In addition to this memorial the V. D. I. annual meeting to be held at Cologne June 27-29 will be in the form of a jubilee celebration, although true to its traditions as a scientific body, scientific events will be the chief attraction. A lecture on radiation problems, emphasizing the relation between engineering and modern physics will be the principal item of the program.

Coffin Fellowships Awarded to College Graduates

Nine college graduates have been granted fellowships for the collegiate year 1931-1932 by the Charles A. Coffin Foundation, a creation of the General Electric Company. The fellowships are to enable the recipients to engage in technical research and post-graduate work in various educational institutions. The recipients are:

J. L. Oncley, of Winfield, Kan., graduate of University of Wisconsin, to study at that institution.

E. E. Postel, of Cleghorn, Ia., a senior at University of Illinois, to study at the University of Iowa.

A. P. Gagge, of Richmond, Va., graduate of University of Virginia, to study at Yale.

G. H. Fritzinger, of Bryant, Ind., graduate of Wittenburg College, to study at Purdue University or at Massachusetts Institute of Technology.

H. E. Darling (Assoc. Student, A. I. E. E.), of Pawtucket, R. I., graduate of Brown University, to study at that institution.

J. P. Fugassi, of Pittsburgh, graduate of Carnegie Institute of Technology, to study at University of Wisconsin.

O. C. Simpson, of Champaign, Ill., graduate of University of Illinois, to study at that institution.

M. Nelles, of Madison, S. D., graduate of University of South Dakota, to study at Harvard.

D. H. Sloan, of San Francisco, graduate of Washington State College, to study at University of California.

Of these men two, Simpson and Sloan, received fellowships under the Foundation last year.

"Plan Your Vacation to Include Tahoe Convention"

As the plans for a splendid technical and social program for the A. I. E. E. 1931 Pacific Coast convention at Lake Tahoe, California, Aug. 25-28, are reaching the final stages, added inducements have developed unexpectedly. These combine with the many program features to make attendance at the convention doubly desirable.

Members of the Institute who plan to combine work and play in their vacation schedule by attending the convention may spend the week preceding or following the convention at Tahoe Tavern with the low convention rates applying during their entire stay. Since the management of Tahoe Tavern has offered the convention the attractive rates of $7.00 to $8.00 per day per person, American plan, many members are planning to take advantage of this splendid opportunity to spend the week-end before or after the convention enjoying the famous Lake Tahoe scenery.

For those traveling by automobile, several scenic routes are available through many points of historic interest. Railroad transportation to the convention is by the Overland Route of the Southern Pacific. Low summer round-trip fares with attractive stopover privileges are available from all parts of the country.

Light and Vision

The February 1931 issue of the *Transactions of the Illuminating Engineering Society* contains an analysis of the literature concerning the dependency of visual functions upon illumination intensity compiled in the form of a report prepared for the national committee on industrial lighting of the national Research Council by Dr. L. T. Troland, Lecturer on Psychology, Harvard University, Cambridge, Mass., and Head of Research Department, Technicolor Motion Picture Corp., Boston, Mass.

Prof. J. W. Barker (F '30, dean of the Columbia University school of engineering) in an editorial, in the same issue, says in part:

"In the paper which forms the body of this issue of the *Transactions*, Dr. Troland has assembled a bibliography of more than nine thousand sources from which he has critically analyzed and correlated the contents. Many portions of this analysis will be of great interest and assistance to the practical engineer, and the analysis in its entirety will serve as a compendium of reference material to which we may refer as an analytical background for much of our specialized work."

The scope of this analysis is indicated by the headings given below, taken from the table of contents of the report in question:

TABLE OF CONTENTS

I. Preface

II. Method and scope of literature search

III. Abstract of the literature bearing on the dependency of visual functions upon intensity of the stimulus

1. General survey of the problem
2. Absolute sensitivity to light
    - References on absolute energy and brightness thresholds
    - References on areal relations of the thresholds
    - References on light and dark adaptation
3. Fechner's law: discrimination of reflection coefficients of large areas
    - References on brightness discrimination threshold
4. Dependency of visual acuity upon illumination intensity
    - References on visual acuity, general
    - References on visual acuity as a function of intensity
    - References on glare
5. Speed of vision as determined by intensity
    - References on speed of vision
6. The dependency of color vision upon intensity
    - References on color and intensity
7. Oculomotor functions, eye-strain, fatigue and injury
    - References on the pupil and other oculomotor functions
    - References on eye-strain and fatigue
    - References on injury to the eye due to light
8. The influence of illumination intensity upon practical operations
    - References on illumination intensity and practical operations
    - Miscellaneous references
9. Summary and conclusion

Prof. Barker, in closing his editorial, says: "In publishing this analysis the Illuminating Engineering Society feels that it is making available to the world a monumental piece of work for which it thanks Dr. Troland the National Research Council."—*An "Illumination Item" contributed by G. S. Merrill, chairman A. I. E. E. committee on production and pplication of light, Nela Park, Cleveland.*

Personal

R. E. Doherty Accepts Yale Professorship

R. E. Doherty (M '27) for many years consulting engineer of the General Electric Company, Schenectady, N. Y., and formerly a personal assistant to Dr. C. P. Steinmetz, will become professor of electrical engineering at Yale University this fall. He will succeed Prof. C. F. Scott (HM '29 and past-president) whose retirement takes place a year from this date. Mr. Doherty is a graduate of the University of Illinois. From the student training course at Schenectady, he worked for two years in the General Electric Company's testing department; then joined the a-c. engineering department as proposition designing engineer. His work attracted the attention of Dr. Steinmetz and in 1920 he chose Mr. Doherty as his assistant. During this period of service with the "electrical wizard" he was doing postgraduate work at Union College and in 1921 he received his master of science degree. In 1922 he became the company's consulting engineer and as such achieved monumental record. In addition to his consulting work he has had charge of the company's advanced course in engineering, a three-year course in design engineering specially planned for a small selected group of college graduates. He was a member of the G. E.'s general education committee and is deeply interested in all educational matters. For three years (1918-19 and 1926-28) he served on the Institute's educational committee. He has been a member also of the A. I. E. E. committees on electrophysics (1924-26) and power transmission and distribution (1928-29); during the period 1926-27 he served as chairman of the Schenectady local Section. He has contributed much also to technical literature.

S. M. Kintner (M '13) for some time assistant vice-president of the Westinghouse Electric and Manufacturing Company was elected its vice-president in charge of engineering at the April 29 meeting of the board. He succeeds W. S. Rugg (M '13) whom the company has made vice-president in charge of sales. As an Institute member, Mr. Kintner has been active on its committees as follows: telegraphy and telephony 1914-15; research 1927-29; representative to National Research Council, engineering division 1928-29; chairman of the research committee and on the board of award of Institute prizes 1929-30.

R. E. DOHERTY

S. M. KINTNER

J. E. OLEM

North Eastern District 1930 Prize Winners

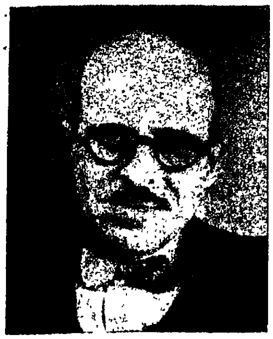
F. K. Fischer, a member of the A. I. E. E. student Branch at Rensselaer Polytechnic Institute received the 1930 Branch Paper prize for his paper "Magnetic and Electrical Properties of Some Chromium Steel Alloys" presented as a part of the program of the North Eastern District meeting at Springfield, Mass., and the basis of the thesis upon which Mr. Fischer earned his E. E. degree at time of graduation June, 1930. This thesis has since been published as a Rensselaer Polytechnic Institute Bulletin, Engineering and Science Series. In July Mr. Fischer joined the student Test Course of the Westinghouse Electric and Manufacturing Company at East Pittsburgh and at present is a member of the Westinghouse Mechanical School of Design run in cooperation with the Graduate School of the University of Pittsburgh.

J. E. Clem (M '30) received the 1930 Best Paper prize of the North Eastern District, A. I. E. E., for his paper "Arcing Grounds and Effect of Neutral Grounding Impedance" presented at the Springfield meeting of the District in May, 1930. Mr. Clem was graduated from the University of Colorado in 1910 with the degree of B. S. in E. E. During the summer of that year he joined General Electric staff in Schenectady, N. Y. In 1922 he went to Japan to supervise the initial installation of 154-kv. transformers in that country, returning in 1925 to become a member of the central station engineering department at Schenectady. Mr. Clem is the author of several Institute papers, and is active in Institute affairs.

F. R. Longley (A '25) received the North Eastern District's 1930 First Paper prize for his paper "The Calculation of Alternator Swing Curves" presented at the District meeting in Springfield in May, 1930. Mr. Longley was graduated from the Georgia School of Technology, Atlanta, in 1923 with the degree of B. S. in E. E. During that summer he joined the General Electric staff in Schenectady where he spent time "on test" and subsequently in the a-c. engineering department. Later, in the central station engineering department he made a special study of stability problems. Mr. Longley left the employ of the General Electric Company in July, 1930, to become associated with the Western Massachusetts Companies with headquarters in Springfield.

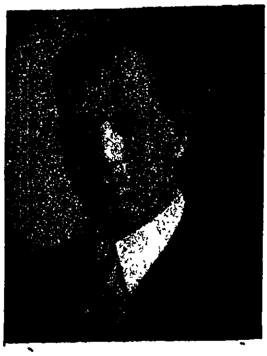
B. M. Jones (M '24) general engineer of the Duquesne Light Company, Pittsburgh Pa., has become the comp ny's planning engineer, and as such will be directly responsible for the planning and development of the Duquesne system as well as the preparation and administration of the capital improvement budget. For many years Mr. Jones has taken an active part in Institute affairs as member of the relay subcommittee and the oil circuit breakers, switches, and fuses subcommittee of the protective devices committee (still serving); and the membership committee of the Pittsburgh Section. He has done considerable work in connection with the committee on uniform procedure for testing oil circuit breakers for interrupting capacity; was joint author with G. B. Dodds in the presentation of "Ground Relay Protection for Transmission System" at the Detroit A. I. E. E. summer convention.

E. J. Jonas (M '23) is the new president of the Central Electric Railway Master Mechanics' Association, Toledo, Ohio. His success as superintendent of the Cincinnati Street Railway Company has made him eminent in mechanical and electrical engineering circles in Cincinnati, as did his work on the standing committee of the Institute's local Section there; he also has served twice on the A. I. E. E. nominating committee. Two years ago he was elected vice-president of the



F. R. LONGLEY

F. K. FISCHER



R. W. E. MOORE

Master Mechanics' association, and its program committee chairman.

Chester Lichtenberg (M '13) who has been intimately identified with technical committees of the Institute, the N. E. L. A., N. E. M. A., and the War Department's procurement planning activities, recently was appointed engineer of the electric refrigeration department at the Fort Wayne Works of the General Electric Company, after nearly twenty-five years with that company in the development of switchboard apparatus, particularly in connection with high-speed air circuit breakers, oil circuit breakers, and selective protective relays.

E. A. Olsen (M '24) formerly vice-president of the Pacific Public Service Company and managing head of its public utility properties serving California, Oregon, and Washington communities, has accepted the position of executive vice-president of the Oklahoma Natural Gas Corporation with offices at Tulsa. Associated with the Insull interests Mr. Olsen held similar office with the Florida Power Corporation and the Georgia Power & Light Company.

R. W. E. Moore (M '17) who until June 1 was with the Westinghouse Company at East Pittsburgh, Pa. as manager of association activities, has been appointed by the National Electric Manufacturers Association to take charge of its publications. For many years Mr. Moore was a member of the Electrical Manufacturers Council as well as chairman of the NEMA Fire Prevention committee.

Alexander E. Bettis (F '26) one of the Institute's directors, and at present serving on its safety code, production and application of light, and transportation committees for 1931, has been chosen president of the Missouri Association of Public Utilities. Mr. Bettis is at present serving the Kansas City Power & Light Company as its vice-president. In 1926-28 he was vice-president of the Institute's South West District.

J. W. Young (A '22) who as engineer of the Narragansett Electric Company went to Providence two years ago to participate in distribution system improvement, has been transferred to the Boston office of the New England Power Association to serve as assistant distribution engineer under W. C. Phillips (M '30) in charge of the development of retail properties of the organization.

W. H. McGrath (M '20) formerly vice-president of the Puget Sound Power & Light Co., Seattle, Wash., has been made its executive vice-president and C. C. Curtis (M '23) previously vice-president in charge of the Fall River Gas Works, Fall River, Mass. has been appointed manager to supervise the Puget Sound Company's operations in its southern, southwestern, and western districts.

Thos. E. Penard (A '08) who during his many years of service with the company has specialized in station design and substation development as head of the electrical division of the Edison Electric Illuminating Company of Boston has been appointed recently to the office of assistant superintendent of its station engineering department.

Gerard Swope, (F '22) addressed the plenary session of the sixth general congress of the International Chamber of Commerce meeting May 4-9, 1931, Washington, D. C., taking as his subject "Regularization of Employment", and presenting the various points of view of company, trade and industry, society, and employe.

L. C. Halpin (A '26) until recently meter superintendent for the Western division of the Niagara Lockport and Ontario Power Company, has been made rural representative of the Angola district in charge of distribution. Mr. Halpin is a member also of the Western Society of Engineers.

Karr Parker (M '24) well known in the Westinghouse organization as president of that company's Agent Jobbers Association, is the newly elected president of McCarthy Bros. & Ford, Buffalo, N. Y., Westinghouse jobbers. He succeeds E. D. McCarthy whose death occurred recently.

H. T. Edgar (M '28) who entered the public utility field in 1886 as an employee of the Edison Electric Illuminating Company of Brunswick, N. J., and for the past thirty-two years associated with Stone & Webster in managerial work extensively throughout the country, has resigned from that organization.

A. M. Chitty (M '22) who has succeeded R. C. Saunders as southwestern district manager of the Puget Sound Power & Light Company, with headquarters at Tacoma, Wash., has a record of long standing with these interests, having been for many years superintendent of the company's traction properties.

Frank W. Smith (M '12) vice-president and general manager of the United Electric Light & Power Company, New York, N. Y. and a former president of the National Electric Light Association, now is vice-president of the New York Edison Company as well.

A. R. Nissar (M '16) principal of the Calcutta Technical School, Bengal, India, left Calcutta the first week in April 1931 for an extended trip to France, Italy, Switzerland, Holland, Germany, and Great Britain.

J. H. Cerecedo (A '20) of the firm of J. H. Cerecedo & Company, Santurce, Porto Rico, Pan-American consultants, has announced the opening of an office in the United States in Chicago, at 105 South La Salle Street.

J. S. Edstrom (F '14) managing director of the General Electric Company interests in Sweden, recently visited the United States as a delegate to the World Congress of the International Chamber of Commerce, Washington, D. C.

R. H. Manahan (M '22) who is chief of the Department of Electricity of the City of Los Angeles and for many years active in the affairs of the International Association of Electrical Inspectors, now has become its national president.

F. R. Phillips (M '27) for some time senior vice-president of the Philadelphia Company was elected president of that company at the April 28 stockholders' meeting.

Obituary

Edward Dean Adams (A '10), engineer, financier, scientist, whose vision, industry, courage, and philanthropy has made possible many achievements of outstanding worth to humanity, including the conception and development of the Niagara Falls hydroelectric system, passed away at his home in New York City May 20, 1931. His death, it is believed, was due almost directly to an automobile accident which occurred while he was en route to Florida in March. Primarily a financier and promoter of innumerable engineering and philanthropic projects, Dr. Adams was born in Boston, Mass. April 9, 1846. From college days on, he has been the recipient of almost countless honors; his degrees (B. S. 1864, M. S. 1897, LL.D. 1906 and M. A. 1908) were followed by titles of both national and international merit including the Royal Order of the Crown of Prussia (1909) and the Médaille de Réconnaissance of the French Republic (1921). In 1926 he received the John Fritz Medal "for great achievement as an engineer, financier and scientist;" he was patron and Life Member of the American Association for the Advancement of Science; patron and Fellow for Life of the American Fine Arts Society; Fellow for Life of the American Geographical Society; and Life Member of the National Geographical Society, the Massachusetts Institute of Technology Alumni Association, the New York Academy of Science, New York Historical Society, Germanistic Society of America, New York Botanical Garden (of which he also was manager and past officer 1912-19), Society of the Sons of the Revolution, New York Geneological and Biographical Society; a Fellow in Perpetuity of the Metropolitan Museum of Art, the Museum of Natural History and the National Academy of Design; a member of the Edison Pioneers; a Fellow and member of the Power Division of the American Society of Civil Engineers; a member of the executive board, engineering division, and electric insulation committee of the National Research Council. Since its inception he has held the chairmanship of the Committee on War Memorial to American Engineers which controlled the building and bestowal of the worldwide famous carillon installed and dedicated at the University of Louvain, Liege, Belgium, July 4, 1928. As a past-officer and director, has included in his activities the promotion of few less than a hundred industrial, educational, and charitable organizations. From 1922 to 1924 he was chairman of the Institute's Edison Medal Committee and from 1916 to the date of his death has represented the Institute on the Engineering Societies' Library Board and in the United Engineering Trustees, Inc. His membership in twenty-seven of the prominent clubs, local and otherwise, including the Engineers Club of New York, the Technology Club (Life Member), Faculty Club of Columbia University, Grolier Club, New York Railroad Club, Lawyers Club, Metropolitan Club, Mendelssohn Glee Club, Economic Club of New York, the Chicago Club and the Adirondack League Club, conveys some intimation of the breadth of application of his activities. Science, art, industry, education, and charity in every community in which he has had his being have benefited by his generosity.

Charles Day (A '02) chairman of the board of Day & Zimmerman, Inc., Philadelphia, Pa., and an expert in plant operation, died at the University Hospital, Philadelphia, May 10, 1931 after an illness of ten days, with which he was stricken a few days subsequent to his return from a trip to North Africa. Philadelphia was his native city; in boyhood he attended the Germantown Academy and in 1899 he was graduated from the department of electrical engineering, University of Pennsylvania. That summer he worked in the engineering department of the National Export Exposition, later associating himself with the Link Belt Engineering Company. As an acknowledged authority on industrial plant equipment and management of public service corporations, he lectured before the Graduate School of Business Administration at Harvard and Columbia universities. At the beginning of the World War he was made trustee of the Emergency Fleet Corporation and during the war served also as a member of civilian board to investigate the efficiency of the Navy Yards. In the winter of 1917 he attended the war council of the Allies and as one of the Storage Committee of the General Munitions Board he conferred with General Pershing and French officials in an effort to speed the transportation of troops and supplies to Europe. He was appointed by the Secretary of War to the Depot Board. He was engineering advisor to Colonel House, a member of the board of management of Franklin Institute, a trustee of the University of Pennsylvania, and a member of the American Society of Mechanical Engineers; also he was a director of the Pennsylvania Railroad, the Philadelphia Fidelity and Trust Company and the United Gas Improvement Company of which his partner Mr. John E. Zimmerman was president. Socially, his memberships included the Engineers' Club (Philadelphia and New York), the Aero Club of America, the Huntington Valley Club and the Raquette Club. His contributions to technical literature were many and his book "Industrial Plants" has had wide circulation.

Stanley L. B. Lines (M '18) vice-president of the Sangamo Company, Ltd., of Toronto, Canada, died at his home there April 9, 1931. He was born in Shire Newton, England in 1884, and received his early education in English private schools. With Brockie Pell Lamp Company, London, he was an honor pupil for three years and also attended evening classes at the City and Guilds Technical Institution for another three years. After completing an apprenticeship with the British Thomson-Houston Company, he joined the technical staff of the Chamberlain & Hookham Company of England, and as its special representative traveled to almost every known continent, finally establishing and managing the Canadian branch of the company at Toronto. In 1919 with Prof. P. M. Lincoln, under whose patents the work was largely carried on, he organized at Toronto the Lincoln Meter Company, Ltd., (producers of a large line of measuring devices) he himself acting in the capacity of vice-president and manager. In 1930 this company was absorbed by the Sangamo Electric Company of Canada, the company of Mr. Lines' final affiliation. His was a long and noteworthy record with the electrical industry of Canada, conspicuous in conjunction with the Canadian Electrical Association and his work as a member of its meter committee. He was past-president of the Electric Club of Toronto, an Associate Member of the Institution of Electrical

Engineers in England, a member of the Association of Professional Engineers of Ontario and belonged to numerous clubs and technical organizations. He was a survivor of the Lusitania disaster.

W. S. Richmond (A '15) secretary, treasurer, and general manager of the Marseilles Land and Water Power Co., Ottawa, Canada, died April 11, 1931. He was a native of Cheshire, Mass. and 50 years of age. Upon graudation from the Adams High School in 1901, he immediately entered upon his technical training at Massachusetts Institute of Technology from which he was graduated with the degree of B. S. in civil engineering June, 1905. Early in 1909 he was first assistant to the resident engineer of the United States government determining the efficiencies of generating units of the Niagara Falls Power Company; later that same year he engaged in a similar capacity at Sault Ste. Marie, Michigan, in connection with government tests of plants of Lake Superior Power Company, the Edison Sault Electric Company and the Lake plants in Michigan. In 1914 the United States government engaged him as resident engineer in full charge of determining efficiencies of generating units in the plants of the Hydraulic Power Company at Niagara Falls. More recently he was civil engineer with the United States Lake Survey (of the War Department) in charge of government surveys of harbors on the east coast of Lake Michigan.

Clark E. Baker (A '21), a member of the transportation engineering department of the General Electric Company at Erie, Pa., and for a number of years a resident of Schenectady, died at his home in Erie on May 11 after a short illness. He was graduate of California Institute of Technology, Pasadena, in 1917 and went to Schenectady in June of that year on the student training course. In September he entered the army engineering corps and continued in service until March, 1919.

Resuming work at Schenectady he was transferred in August, 1919, to the company's railway engineering department, specializing on substation equipment applications. In September, 1929, he moved to Erie with the department and was placed in charge of the substation section.

He was born at Paw Paw, Illinois, December 19, 1894, but the family early removed to Santa Ana, California, where both parents now are living. He is survived by his wife, Myrtle Van Allen, and two children, a boy of 7 and a girl of 5. He was active in American Institute of Electric Engineers affairs, serving on committees and contributing to the proceedings. Interment was at Santa Ana, California.

Robert McRae Wilson (A '24) electrical engineer of the General Electric Company, Bloomfield, N. J. and resident of Montclair, N. J., died suddenly April 24, 1931, while in Savannah, Ga. on a motor trip. He was a native of Beaufort, S. C., but his technical education was acquired in the State of New York—two years at City College of New York and the regular four-year course at Cornell University from which he was graduated in 1896. The following year he engaged with the Hyer Sheehan Electric Motor Company of Newburgh, N. Y., for eighteen months general engineering and estimating work; then he joined the Sprague Electric Company at Bloomfield, N. J. The next year he became instructor in electrical engineering at Lehigh University, but at the end of one semester returned to the Sprague company and remained with it after it became the Sprague Electric Works of the General Electric Company; later the Bloomfield Works of that company. Mr. Wilson's term of service, extending over a period of thirty years, included considerable specialized work on d-c. motor and generator design.

Edward B. Plenge (A '22) electrical engineer of the waterwheel generator section of the a-c. engineering department of the General Electric Company, Schenectady, N. Y., died April 3, 1931 due to injuries sustained by being struck by an automobile. He was born in Charleston, S. C. in 1886, and was graduated from Clemson College in 1907, having completed its course in electrical engineering. In August of that year he engaged in the G. E. Test Course at the Schenectady works, and in October 1909 joined the a-c. engineering department of the company, where he has remained in continuous service. He has had charge of the design work on waterwheel-driven generators for a number of years during a period when General Electric achievement in this field included generators for the Conowingo Dam, the 65,000-kw. units at Niagara Falls, and the 77,500-kw. units for the U. S. S. R. Mr. Plenge's home was in Scotia, New York, where he was held in high esteem by both his professional and personal friends. He was a member of the Edison Club and of the Schenectady Country Club.

McKee Duncan (A '14) consulting engineer of Duncan, Young & Company, New York City, met with sudden death on the public golf course at Van Cortlandt Park there. He was 43 years of age. In 1910 the degree of B. S. was conferred upon him by Columbia University; later in that same year he went to Europe for graduate work in physical chemistry at the University of Leipzig. Returning to the United States in 1911, he continued the study of physical chemistry at the University of Wisconsin. His early commercial connection brought him in close association with Dr. Louis Duncan as a member of the firm of Duncan, Young & Pressey, Inc., predecessors of the company of his last affiliation, and was heartily endorsed by him for membership in the Institute after a friendship which had endured for over twenty years.

Joseph T. Blondin (A '18) director of the Revue Générale de l'Electricite, France, passed away at the home of his son in Paris, April 21, 1931. He was in the 68th year of his age. Born in Dieppe, he led a most active professional career, held in high esteem by his countrymen. He was well-known as an electrical engineer, and bore the honorary titles of Officer d'Academie, Officer de l'Instructions Publique and Chevalier du Merite Agricole. He was also professor of mathematics and professor of physics at several of the representative universities of France, including Orleans and the College of Rollins. Many of the French technical publications were issued under his directorate.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicat them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Collinot, Marcel A., 88 Sherman Ave., Newark, N. J.

DiLucci, A., Box 1051, Chicago, Ill.

Duane, George B., Otis Elevator Co., Yonkers, N. Y.

Muncy, V. E., Ohio Mechanics Institute, Cincinnati, Ohio.

O'Shea, V., Jr., 115 Broadway, New York, N. Y.

Tung, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Local Meetings

Florida Section Organized

At its meeting held on January 28, 1931, the Institute's board of directors authorized the formation of the Florida Section to cover the entire state.

This Section held an organization meeting March 27th, at which the following officers were elected: Prof. Joseph Weil (A '24) chairman; C. S. Hammatt (M '23) vice-chairman; R. P. Smith, secretary-treasurer; H. N. Fairbanks, member executive committee.

Student Convention at Rose Polytechnic Institute

The annual student convention of the Branches at Purdue University, University of Illinois, and Rose Polytechnic Institute was held at Rose Polytechnic Institute April 18, 1931; total attendance 120.

The afternoon was devoted to an inspection trip to the Dresser plant of the Indiana Electric Corporation, and the mine operating in conjunction with it. Addresses of the evening were:

Railway Electrification, by W. D. Bearce (M '30), General Electric Company.

The Operation of Large Electric Power Plants, by L. B. Andrus (F '19) president, Indiana Electric Corporation.

North Central District Holds Student Activities Conference

The fifth annual conference on student activities in District No. 6 was held at the University of North Dakota (Grand Forks) on April 17-18, 1931. Of the nine schools in the District, eight were represented by both counselors and chairmen.

Friday Evening

In the absence of Thomas F. Kane president of the University of North Dakota, the address of welcome was given by Dr. William G. Bek, dean of the junior division. Dean H. S. Evans (M '09) vice-president, District No. 6, responded for the delegates and then presided during the presentation of the following program:

Report of summer convention of the A. I. E. E. held June 1930 at Toronto, Ont., Canada, by Prof. G. H. Sechrist (A '20) counselor, University of Wyoming Branch, and chairman of the district committee on student activities.

Personal Qualities Which a Branch Chairman Should Develop to be a Successful Leader of His Branch, Prof. W. C. DuVall (M '20) counselor, University of Colorado Branch, Prof. F. W. Norris (M '26) counselor, University of Nebraska Branch.

Formal discussion presented by Neil Sanders, chairman, University of Wyoming Branch.

The Effect of Electricity Upon the Human Body, by R. B. Witmer, Asst. Prof. of Physics, University of North Dakota.

After the completion of the program the business meeting of the counselors and an informal meeting of the Branch chairmen were held in parallel session. Prof. G. H. Sechrist (A '20) chairman, District committee on student activities, presided at the former.

The counselors decided that the sixth annual conference will be held in the spring of 1932 at the University of Denver.

Prof. H. F. Rice (A '21) counselor, University of North Dakota Branch was elected chairman of the committee on student activities for the ensuing year and delegate to the summer convention at Asheville. Prof. D. R. Jenkins (A '16) counselor, University of North Dakota Branch was elected alternate delegate.

Saturday Morning

Vice-president Evans presided.

Should Qualifications for the Grade of Enrolled Students be Established?, by Prof. B. B. Brackett, counselor, University of South Dakota Branch.

Formal discussion presented by B. J. Shields, chairman, University of North Dakota Branch.

Should Attendance at Student Branch Meetings be Made Compulsory and Credit Given for this Work?, by Prof. H. F. Rice, counselor, University of North Dakota Branch, presented by Charles C. Libby.

Formal discussion presented by A. Steponaitis, University of South Dakota Branch.

What the Prospective Employer Looks for in the Engineering Graduate, by Prof. H. S. Rush (M' 30) counselor, North Dakota Agricultural College Branch.

Formal discussion presented by Almon Bjerke, chairman, South Dakota State School of Mines Branch.

What Can the Institute do Through Its Branches to Inform High School Students of the Opportunities and Need for Trained Electrical Engineers, by Prof. J. O. Kammerman (M' 20) counselor, South Dakota State School of Mines Branch.

Formal discussions presented by R. M. Partington, chairman, University of Colorado Branch, and H. H. Ward, chairman, University of Denver Branch.

How Best May the Branch Serve in the Development of Its Members as Engineers?, by Prof. R. E. Nyswander (M '22) counselor, University of Denver Branch.

Formal discussions presented by Phil Ehrenhard, chairman, University of Nebraska Branch, and C. E. Bryant.

San Francisco Section Meets with Branches

The annual joint meeting of the San Francisco Section and the student Branches at the University of California, University of Santa Clara, and Stanford University was held on the Stanford campus April 17, 1931; attendance 165.

In the afternoon visits to engineering laboratories and shops were concluded by a demonstration of high-voltage flashover at the Ryan High-Voltage Laboratory.

During the dinner held in Stanford Union, entertainment was furnished by the Branches; an address of welcome was given by Theodore J. Hoover, dean of the School of Engineering, and Dr. Harris J. Ryan (F '23) executive head of the department of electrical engineering and past-president of the A. I. E. E., spoke on the establishment of the student Branches of the Institute.

The evening's technical program presented by students was as follows:

Vacuum-Tube Voltage Regulators, by Edwin W. Palmrose, senior, University of California.

Development of Television, by Charles Harvey and Lionel Thorpe, juniors, University of Santa Clara.

Corona and Transmission-Line Surges, by Hugh H. Skilling, graduate student, Stanford University.

The prize of one year's Associate's dues in the Institute was awarded to H. H. Skilling.

Past Section Meetings

Baltimore

The Holtwood Hydraulic Laboratory and Its Contribution to the Design of the Safe Harbor Development, by G. W. Spaulding, Pennsylvania Water and Power Co.;

Construction of the Safe Harbor Development, by C. W. Black, The Arundel Corp. Inspection trip to the Safe Harbor Hydroelectric Project. Joint meeting with the Engineering Societies of Baltimore. April 23. Attendance 300.

Birmingham

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of

Virginia, and vice-president, District No. 4, A. I. E. E. March 20. Attendance 7.

Boston

Performance of High-Tension Cable, by F. Malcolm Farmer, Electrical Testing Laboratories. Buffet supper served prior to the meeting. April 24. Attendance 100.

Cleveland

Human Relations in Industry, by Whiting Williams. E. C. Stone, The Philadelphia Co., and vice-president, District No. 2, A. I. E. E. gave a short talk on Institute activities. Two papers were presented by students as follows:

The Cathode-Ray Oscillograph, by J. F. Matyas;

Bridge-Circuit Control of Thyratron Tubes, by I. J. Rand. Joint meeting with the Case School of Applied Science Branch. April 15. Attendance 101.

Columbus

Audible Light and Visible Sound, by John B. Taylor, General Electric Co. Demonstrations. March 27. Attendance 250.

Connecticut

Talks on electrical control of temperature by O. H. Hunt, T. F. Herring, J. J. Carney, and P. A. Borden, all of the Bristol Company's engineering staff. April 14. Attendance 50.

Dallas

Modern Developments in Communications, by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. Illustrated. Joint meeting with the Dallas Electric Club. April 13. Attendance 340.

Denver

Annual College Night at which the following papers were presented by students:

New Ideas for High-Voltage Circuit Breakers, by Charles A. Church and Neil R. Damon, University of Colorado;

The Life of Faraday, by Oscar Bear, Colorado Agricultural College;

Variation with Temperature of the Magnetic Properties of Iron and Nickel, by Harry H. Ward and Gerald O. Cannon, University of Denver. April 24. Attendance 110.

Detroit-Ann Arbor

The 1,000-Deg. Turbine, by Paul W. Thompson, Detroit Edison Co. There was an inspection of the new Delray Power House and the 1,000-deg. turbine. April 21. Attendance 250.

Erie

Hoboken Electrification of D. L. & W. Railroad, by Edward L. Moreland, Jackson & Moreland. Dinner preceded the meeting. April 21. Attendance 150.

Fort Wayne

Saturated Reactor and Capacitor Circuits, by C. M. Summers and L. F. Hemphill, both of the General Electric Co. April 16. Attendance 60.

Indianapolis-Lafayette

Research and Industry, by E. L. Manning, General Electric Co. Demonstration of the thyratron tube. April 10. Attendance 280.

Iowa

Trend in the Design of Principal Electrical Features of Steam Power Stations, Substations, and Transmission Lines, by H. W. Eales, Byllesby Engineering and Management Corp. Illustrated with lantern slides. April 16. Attendance 35.

Ithaca

Some Recent Developments in Radio Receiver Tubes, by Walter R. Jones, Sylvania Products Co. March 20. Attendance 50.

Lehigh Valley

The Home Lighting Story, by Lilliam E. Eddy, Edison Lamp Works;

When Electricity is the Master Servant, by Clara Zillessen, Philadelphia Electric Co. Illustrated. Ladies' Night held at the Hotel Americus, Allentown, Pa.

Los Angeles

Discussion and demonstration of sound-recording and reproduction as practised in the motion picture industry. Speakers: R. H. Townsend, RCA Photophone Company, H. C. Silent and J. H. Frayne, Electrical Research Products, Inc. Illustrated by lantern slides and talking motion pictures. April 14. Attendance 426.

Louisville

Inspection trip through the Axton-Fisher Tobacco Co. May 8. Attendance 55.

Lynn

Changing Views of the Nature of Matter, by Saul Dushman, General Electric Co. March 18. Attendance 450.

The twentieth annual banquet. March 28. Attendance 460.

Discussion on Radio Tubes, by O. H. Biggs, A. C. Rockwood, G. D. O'Neil, all of the Hygrade Lamp Co. April 8. Attendance 300.

Madison

Modern Electroplating, by J. G. Zimmerman, Burgess Laboratories;

Chromium Plating—The Electroplate that is Different, by Professor O. P. Watts, University of Wisconsin. Inspection trip to the Scanlan-Morris Company's plant. April 29. Attendance 27.

Mexico

Ericssen System of Long-Distance Telephony, by Helge F. Rest, Ericssen Company. April 14. Attendance 22.

Minnesota

Factors Affecting Noise Induction Between Power and Telephone Circuits, by F. R. Kappel, Northwestern Bell Telephone Co. April 29. Attendance 150.

Niagara Frontier

Art in Industry, by D. R. Dohner, Westinghouse Elec. & Mfg. Co.;

Quick-Trip Graphic Meters and Their Application, by D. J. Angus, Esterline-Angus Co. Illustrated. Election of officers as follows: R. W. Graham, chairman; E. S. Bundy, vice-chairman; G. W. Eighmy, secretary-treasurer, H. B. Vidal and G. W. Brooks, members executive committee. April 17. Attendance 50.

Oklahoma City

Telegraphic Pilot-Wire Relay System, by J. D. Browder, Oklahoma Gas & Electric Co. and E. B. Jennings, Southwestern Bell Telephone Co. April 29. Attendance 61.

Pittsburgh

Electric-Arc Furnace Installations, by Samuel Arnold, American Bridge Co.;

Arc-Furnace Control, by C. C. Levy, Westinghouse Elec. & Mfg. Co. Illustrated with lantern slides. Joint meeting with the Engineers' Society of Western Pennsylvania. April 14. Attendance 93.

Philadelphia

Speed, Unemployment, and Progress, by William McClellan, Stone & Webster Engg. Corp. April 13. Attendance 150.

Portland

Application of Vacuum Tubes, by A. W. Copley, Westinghouse Elec. & Mfg. Co. Demonstrated. Joint meeting with the N. E. L. A. March 16. Attendance 96.

Waves or Particles, by A. A. Knowlton, Reed College. Joint meeting with the N. E. L. A. April 21. Attendance 90.

Providence

Magic Tubes, by Prof. F. N. Tompkins, Brown University. Dinner in honor of the speaker preceded the meeting. March 10. Attendance 220.

Rochester

New Developments in Vacuum Tubes, by Eugene W. Ritter, RCA Radiotron Co. Joint meeting with the I. R. E. April 16. Attendance 97.

In Years to Come, by James G. Harbord, Radio Corporation of America. Tenth annual dinner of the engineering societies of Rochester. April 18, Attendance 395.

St. Louis

Introduction of Higher Speed into Transmission Line Protection, by W. E. Winterhalter, General Electric Co. Election of officers for term 1931-32 as follows: C. H. Kraft, chairman; F. B. Wipperman, vice-chairman; C. H. Lankford, secretary. April 15. Attendance 60.

San Antonio

Lightning and Lightning Protection, by P. F. Squier, Westinghouse Elec. & Mfg. Co. Illustrated. April 13. Attendance 32.

Sharon

Hon. Frank Crowther, U. S. Congressman from New York, discussed the problems presented to the last Congress. Before the meeting there was an inspection trip through the McDonald Plant of the Carnegie Steel Co. Joint meeting with the Association of Iron and Steel Electrical Engineers. April 15. Attendance 310.

The Contribution of Telephone Research to Talking Motion Pictures, by J. O. Perrine, American Telephone & Telegraph Co. Illustrated. May 5. Attendance 240.

Spokane

A Progress Report on a Short Circuit Model of the Washington Water Power Company System, by Clarence L. Holmes, State College of Washington;

Short-Circuit Transients In Synchronous Generators, by Robert Pennoyer, University of Idaho;

Fundamentals of Carrier Telephony, by Loren A. Traub, Home Telephone & Telegraph Co. Dinner preceded the meeting. April 24. Attendance 46.

Springfield

Grounding the Neutral, by W. W. Lewis, General Electric Co. Illustrated. March 19. Attendance 56.

Electrotherapy, by William Bierman, president, N. Y. Physical Therapy Society. April 13. Attendance 52.

Toledo

System Regulation, by T. J. Nolan, Toledo Edison Co.;

Storage Batteries, by W. E. Dunn, Electric Storage Battery Co. Illustrated. April 17. Attendance 45.

Toronto

Interesting Developments and Problems in Central Station Engineering, by R. E. Powers, Westinghouse Elec. & Mfg. Co. Joint meeting with Engineering Institute of Canada. April 24. Attendance 250.

Annual meeting. French Faience, by C. H. Mitchell, University of Toronto. Illustrated. Election of officers as follows: T. W. Eadie, chairman; G. D. Floyd, secretary. May 1. Attendance 43.

Utah

Miracles from the House of Magic, by H. T. Plumb, General Electric Co. Inspection of the laboratories at University of Utah followed by dinner. April 9. Attendance 470.

Vancouver

Starting Conditions in Synchronous Machines and an Analysis of the Synchronous-Induction Motor, by H. Vickers, University of British Columbia. April 6. Attendance 33.

Inspection of Ruskin Hydroelectric Development of the British Columbia Electric Railway Co. April 25. Attendance 64.

General Developments in the Bell Telephone Laboratories, by C. C. Pettet, Northern Electric Co. May 4. Attendance 41.

Washington

Lightning and Lightning Arresters, by M. G. Lloyd, Bureau of Standards. Orville S. Peters was presented with the John Scott Award for the invention and development of the electric telemeter. April 14. Attendance 94.

Worcester

Copper from Mine to Consumer, by William H. Bassett, Jr., Anaconda Wire & Cable Co. Joint meeting with the A. S. M. E.

Fused Quartz, by A. L. Ellis, General Electric Co. May 12. Attendance 40.

Past Branch Meetings

Alabama Polytechnic Institute

Election of officers as follows: W. H. Mimns, chairman; T. N. Pyke, vice-chairman; G. F. Fuker, secretary. April 23. Attendance 17.

University of Alabama

Business meeting. April 27. Attendance 15.

University of Arizona

X-Rays and Their Application, by Paul F. Hawley, student. April 10. Attendance 6.

University of Arkansas

Demonstration of a color organ was given by Professor Wesley Roberds, Physics Dept. April 23. Attendance 22.

Armour Institute of Technology

Film—"The Single Ridge." May 1. Attendance 51.

Polytechnic Institute of Brooklyn

Electrons and Sub-Electrons, by Dr. Ernst Weber. April 23. Attendance 42

California Institute of Technology

Power Systems of Germany, England, and France, by Professor W. T. Ryan, University of Minnesota. April 16. Attendance 35.

University of California

Russian Five Year Plan, by Robert Sibley, University of California Alumni Association. Joint meeting with the A. S. M. E. Branch. April 8. Attendance 55.

Carnegie Institute of Technology

Sound Motion Pictures, by Carl Long, student;

Underground Cables, by Thomas Zima, student. Election of officers as follows: Walter B. Wigton, chairman; H. A. Wagner, vice-chairman; F. A. Lennberg, secretary; S. J. Myers, treasurer. April 15. Attendance 22.

University of Cincinnati

Life of Joseph Henry, by D. Michael, student. Illustrated lecture on Electric Ship Propulsion. Election of officers as follows: W. Kock, chairman; H. Koerber, vice-chairman; Mr. Schmidt, secretary; Mr. Manning, treasurer. April 21. Attendance 23.

Clarkson College of Technology

Inspection trip to the sawmill of the Elliott Hardwood Co., Inc., at Potsdam. April 8. Attendance 12.

Colorado State Agricultural College

Inspection trip to the Valmont electrical plant of the Public Service Co. of Colorado. April 24. Attendance 11.

University of Colorado

New Developments in Engineering, by Wm. Trudgian, Westinghouse Electric & Mfg. Co. Film—"Westinghouse Steam Turbines." April 1. Attendance 38.

Annual College Night held jointly with the Denver Section. (For complete report see "Past Section Meetings.")

Cornell University

Talks on the life of Faraday by four students. Election of officers as follows: Randall A. Smith, chairman; Wm. S. Bachman, secretary-treasurer. April 22. Attendance 23.

Drexel Institute

Potentiometer Pyrometer, by Fred C. Haish, student. April 21. Attendance 34.

An explanation and description of the Reading R. R. suburban electrification and Wayne Junction substation construction was given by S. I. Croney, student. May 5. Attendance 10.

Duke University

Courier Systems Used in Telephone Communications of Power Companies, by S. G. Flack, student. Election of officers as follows: S. G. Flack, chairman; A. L. de Bruyne, vice-chairman; J. A. Womack, secretary-treasurer. May 5. Attendance 15.

Georgia School of Technology

Lighting, by Mr. Horton, General Electric Co. April 8. Attendance 113.

Harvard University

Engineering Students and the Management of Men, by Professor E. D. Smith, Yale University. April 24. Attendance 30.

University of Iowa

Four reels of motion pictures on telephone communications were shown. April 15. Attendance 42.

University of Florida

Lighting Design, by John W. Wilson, student. April 13. Attendance 23.

Election of officers as follows: R. E. Walker, chairman; J. C. Huffer, vice-chairman; L. P. Barnett, secretary-treasurer. April 20. Attendance 21.

Kansas State College

The Successful Engineer, by Professor L. M. Jorgenson. April 9. Attendance 67.

The same program was presented at the evening meeting. April 9. Attendance 41.

The Engineering Field, by H. S. Kilby, Kansas Power Co. Film—"The Benefactor." April 23. Attendance 40.

The same program was presented at the evening meeting. April 23. Attendance 70.

The Design of Telephone Outside Plants, by E. C. Kuhlman, Southwestern Bell Telephone Co. May 7. Attendance 73.

The same program was presented at the evening meeting. May 7. Attendance 40.

University of Kansas

Banquet. Attendance 146.

Life of Michael Faraday, by Charles Brecheisen, student;

Life of Joseph Henry, by Clifford Hamel, student. The Branch was presented with the Sigma Tau cup for the best exhibits in the engineering exposition. May 7. Attendance 47.

Lafayette College

Business meeting. May 2. Attendance 25.

Lewis Institute

Description of the electrification of the suburban division of the Illinois Central Railroad Co., by C. H. Mottier, of that company. April 3. Attendance 151.

University of Louisville

Life of Joseph Henry, by Mr. Friedman, student;

Life of Faraday, by Mr. Knoop, student. Mr. Cook, student, reviewed the achievements of 1930. March 20. Attendance 15.

University of Maine

Radio, by Walter J. Creamer, student. April 9. Attendance 22.

Election of officers as follows: R. E. Young, chairman; Gerald Frost, vice-chairman; Roland J. Tibbetts, secretary; Thomas Morrison, treasurer. April 21. Attendance 16.

Vacuum Tubes and Their Industrial Applications, by Oliver Ajer, General Electric Co. Demonstration of the operation of the photoelectric cell and the thyratron. April 23. Attendance 160.

Marquette University

Executive board meeting. March 26. Attendance 7.

Switches and Switching, by J. D. Greensward, Allis-Chalmers Co.;

Personality in Engineering, by H. S. Day, Wisconsin Telephone Co. Annual banquet. April 9. Attendance 50.

Massachusetts Institute of Technology

The PiezoElectric Oscillator in the Power Industry, by B. H. Buckingham; student;

Radio in Aeronautics, by J. G. Ritchey, student. April 14. Attendance 50.

Michigan College of Mining and Technology

Faraday and His Early Experiments, by Oscar Hane, student;

The Early History of Electricity, by William Keyes, student. March 25. Attendance 15.

Michigan State College

Demonstration and explanation of the control device called the "Telemat," by W. H. Bliss, instructor. April 14. Attendance 23.

Talks on the life and work of Faraday and Henry, by E. Moore and J. Young, students. Election of officers as follows: Edwin W. Moore, chairman; John Young, vice-chairman; Webster Bowler, secretary-treasurer. April 28. Attendance 24.

University of Michigan

Experiences with the Detroit Edison Co., by William S. Thomas, student. April 29. Attendance 28.

School of Engineering of Milwaukee

Substations and Substation Metering Equipment, by William Duhn, instructor;

Vacuum Tubes and Their Use in Medicine, by Wm. P. Gainer, Branch chairman. Film—"The Single Ridge." April 8. Attendance 45.

Missouri School of Mines and Metallurgy

The Application of the Photoelectric Cell, by M. R. James, student;

Hydroelectric Developments, by Professor I. H. Lovett, counselor. April 15. Attendance 24.

Inspection trip to the Bagnell Dam. April 18. Attendance 43.

Six films shown as follows: "Telephoto Equipment," "Television," "Electric Heat in Industry," "Induction Voltage Regulators," "Oil Circuit Breakers," and "The Automatic Substation." April 22. Attendance 24.

Montana State College

Banquet given in honor of Dean H. V. Carpenter, University of Washington, and vice-president, District No. 9, at which he delivered an address entitled Continuity of Service. April 9. Attendance 39.

Man and His Machines, by Dean H. V. Carpenter. April 9. Attendance 164.

Electric Communication and the New York Stock Exchange, taken from Electrical Engineering, presented by C. G. Anderson, student;

Cracking Oil by Electricity, taken from Electrical Engineering, presented by Eric N. Blannin, student;

Inspection of Arc Welds, by Edgar Dolum, student;

Two Elevators in One Shaft, taken from *Electric Journal*, presented by Leonard Estey, student. April 16. Attendance 125.

Election of officers as follows: Homer Lambdin, chairman; Jean Smith, vice-chairman; Wesley Funk, secretary; William Scheele, treasurer. April 21. Attendance 30.

Private-Wire Telegraph Service, taken from Electrical Engineering, presented by James Graybeal, student;

Maintenance of Distribution Systems, by Arthur W. Buckley, student;

Railroads vs. Transmission Lines, taken from Electrical Engineering, presented by W sley Funk. April 23. Attendance 120.

Ventilating Electrical Galleries, taken from *Electrical World*, presented by Curtis Hanson, student;

Recent Uses and Developments of Electricity in Transportation, by Armin J. Hill, student;

Radio Beacon Guides Planes, by Homer Lambdin, student. April 30. Attendance 114.

Inspection trip to the Anaconda Copper Mining Company; Morony, Volta, Rainbow, and Black Eagle power plants of the Montana Power Co.; Claude Neon Sign Works; Automatic telephone exchange of the Mountain States Tel. & Tel. Co.; and radio station KFBB. May 4-6. Attendance 29.

Analysis of Radio Interference, by W. H. Bato, student;

Treating Rewound Motors, by Carl Wall, student;

Current Collection in Hydrogen Atmosphere, by Jean Smith, student. May 6. Attendance 77.

University of Nevada

Engineering Economics, by J. Hough, student;

New Developments in Synchronous Motors, by Clarence Jones, student. April 4. Attendance 13.

The Use of Hydrogen in Rotating Electrical Apparatus as a Cooling Medium, by E. H. Tucker, student. April 15. Attendance 24.

Newark College of Engineering

Mercury Arc Rectification, by Paul Dumont, General Electric Co. Election of officers as follows: E. Olsta, president; J. G. Woehling, vice-president; M. Barker, treasurer. April 20. Attendance 25.

University of New Hampshire

The Problems of Telephone Transmission, by O. W. Eshbach, American Tel. & Tel. Co. April 10. Attendance 103.

Vacuum Tubes, by Oliver Ajer, General Electric Co. Demonstrations. April 21. Attendance 83.

College of the City of New York

Eighth annual dinner. April 9. Attendance 112.

Electric Drive of Ships, by Frank V. Smith, General Electric Co. April 16. Attendance 20.

North Carolina State College

Election of officers as follows: G. E. Ritchie, chairman; J. W. Southerland, vice-chairman; L. C. Hubbard, secretary. April 14. Attendance 28.

Radio Frequency Amplifiers, by W. S. Smith, student. May 12. Attendance 21.

University f North Carolina

Radio Applications, by R. V. Whitener, student. Election of officers as follows: D. J. Thurston, Jr., chairman; R. C. Cadmus, vice-chairman; Lloyd Swain, treasurer; Sam Barham, secretary. April 23. Attendance 41.

North Dakota State College

Election of officers as follows: Clarence Bryant, chairman; Fred Payne, vice-chairman; Ralph Simenson, secretary-treasurer. April 13. Attendance 13.

Life of Steinmetz, by Andrew Fritch, student. Film—"Electric Welding." Joint meeting with A. S. M. E. April 16. Attendance 66.

Film—"Dynamic America." Joint meeting with A. S. M. E. and College Engineers' Club. April 30. Attendance 57.

University of North Dakota

Film—"The General Electric Test Course." April 29. Attendance 15.

University of Notre Dame

Substation Design, by E. P. Kreimer, Indiana Michigan Electric Co. Patrick Murray, student, presented the regular engineering news review. April 13. Attendance 46.

Application of Electricity to Metallurgy, by Edward G. Mahin, chemistry dept.;

The Mechanical Larynx, by Charles Podlaski, student. Patrick Murray, student, presented the engineering news review. Election of officers as follows: Hugh Ball, chairman; J. Andres, vice-chairman; F. A. Consolati, secretary; L. R. Rohlof, treasurer. April 27. Attendance 56.

Oklahoma A. & M. College

Power Distribution in City Limits, by V. A. Pendelton, Oklahoma Gas & Electric Co. Election of officers as follows: Joe Hutchinson, chairman; L. C. Hanan, vice-chairman; Clyde Benson, secretary. April 24. Attendance 40.

Oregon State College

Engineering Practise, by E. D. Searing, Portland General Electric Co. April 30. Attendance 33.

Pennsylvania State College

College Illumination, by Professor D. L. Markle. April 22. Attendance 14.

Pratt Institute

Films—"Conowingo" and "Steam Turbine with a Solid Rotor." April 15. Attendance 23.

Mr. Muldaur, National Fire Underwriters' Laboratories, spoke on the testing and setting of standards for mechanical and electrical equipment, and also gave a brief outline of the development of the association and its uses to the public April 23. Attendance 150.

Purdue University

History of Michael Faraday's Life, by M. F. Droege, student;

Experiments by Michael Faraday, by Paul E. Duff, student. W. P. Hallstein and C. C. Fisher, students, gave a demonstration on the operation of a tesla coil. April 28. Attendance 100.

Rhode Island State College

Election of officers as follows: Leon C. Breault, chairman; Byron A. Porter, vice-chairman; Lloyd E. Crandall, Secretary-Treasurer. April 15. Attendance 15.

Rice Institute

Television, by Mr. Kennedy, student. April 15. Attendance 20.

University of Santa Clara

Election of officers as follows: Lionel W. Thorpe, chairman; John Pocharich, vice-chairman; Thomas Eberhard, secretary-treasurer. April 30. Attendance 21.

University of South Carolina

Business meeting. April 13. Attendance 13.

The Engineer and His Connection with Sanitation, by Col. A. E. Legare, supervisor, Dept. of Health. April 20. Attendance 31.

Michael Faraday, by L. E. Rankin, student;

Charles P. Steinmetz, by C. Urquhart, student. April 27. Attendance 35.

South Dakota State School of Mines

Professor J. O. Kammerman, counselor, Almon Bjerke, Branch secretary, and Charles Laws, Branch chairman, gave reports of the fifth annual conference of student Branches of District No. 6. April 22. Attendance 36.

Stevens Institute of Technology

Submarines, by R. C. Welles, student. April 16. Attendance 25.

Syracuse University

Busbar Stresses, by Oliver Bigsby and Edwin Hinchliffe, students;

Scott Connection for Autotransformers, by Lyndon Depew and W. Kleppinger, students. April 17. Attendance 25.

University of Texas

Inspection of the electrical equipment of the Norwood Building, Littlefield

Building, and Austin Power Plant. April 9. Attendance 18.

University of Utah

Election of officers as follows: Richard C. Hansen, chairman; Philip J. Elsey, vice-chairman; W. S. Nishiyama, secretary-treasurer. April 21. Attendance 37.

University of Vermont

Hydrogen Cooling of Rotating Electrical Machinery, by E. J. Mercier, student. April 14. Attendance 22.

Films—"A Concrete Example," "The Telephone Repeater," "Something About Switchboards," and "The World's Telephone Workshop." April 21. Attendance 40.

Election of officers as follows: Donald E. Child, chairman; C. B. Cross, vice-chairman; Robert A. Hyde, secretary-treasurer. April 28. Attendance 24.

Virginia Military Institute

Television, by R. P. Sledge, student;

A Floating Power Plant, by J. C. Shell, student;

Future of Electricity, by H. J. Geiger, student. April 18. Attendance 50.

Virginia Polytechnic Institute

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. May 5. Attendance 51.

University of Virginia

The History and Development of the Telephone, by B. G. Switzer, student. April 7. Attendance 17.

University of Washington

Television, by Carl Johnson, student. April 9. Attendance 13.

"Ruby" the Next Development of the Skagit, by J. D. Ross, former Superintendent of Lighting, City of Seattle. April 16. Attendance 213.

Washington State College

Direct Coupled Amplifiers, Their Construction and Use, by L. N. Hatfield, Branch chairman. May 1. Attendance 22.

Washington University

Election of officers as follows: D. A. Fischer, president; Charles L. Cline, vice-president; Ernest A. Wolff, secretary-treasurer. April 30. Attendance 16.

West Virginia University

The following talks given by students were based on a recent inspection trip:

Westinghouse High Voltage Laboratory, by H. O. Webb;

H. J. Heinz Co., by J. R. Nottingham;

American Bridge Co., by J. E. Newcomer;

Motors for the P. R. R. Electrification, by C. Malone;

New Power Plant in South Carolina, by H. V. Locker;

Pittsburgh Transformer Works, by F. E. Watson. April 21. Attendance 32.

The following talks given by students were based on a recent inspection trip:

Jones & Laughlin Steel Corp., by G. Pride;

Mesta Machine Co., by S. Boone;

Electrical Communication in N. Y. Stock Exchange, by C. DeLancy;

Synchronous Motors for Ship Propulsion, by P. Steenbergen;

Propeller Type of Pumps, by C. Withers;

Bell Telephone Co., by A. Fervier;

Electrification of the Pennsylvania R. R., by W. Unger;

Eddy Currents, by G. Lefevre. April 28. Attendance 32.

University of Wyoming

Election of officers as follows: Neil Sanders, chairman; T. Hance, vice-chairman; Roy Perkins, secretary-treasurer. April 7. Attendance 10.

Life of Faraday, and Circuit Breakers, by Reece Achenbach, student. May 5. Attendance 8.

Yale University

Election of officers as follows: Ludwig B. Hansen, chairman; J. A. Keyser, sreasurer; F. M. Wolff, secretary. May 1. Attendance 16.

Employment Notes

Of the Engineering Societies Employment Service

Positions Open

ELECTRICAL ENGINEER with experience in designing a-c. and d-c. machines. Apply by letter giving qualifications. Location, vicinity of New York City. W-2753.

YOUNG MAN with training and experience in patent and trade mark law, who would like to work himself into the patent and trade mark problems of a large chemical firm. Apply only by letter. Location, New York. W-2018.

Men Available

ELECTRICAL ENGINEER with 15 years' experience in design, construction, reports and editorial work. Now engaged on special publishing job; will be available for publicity or editorial work on trade publications. References from leading engineering and publishing firms. B-4022.

1930 TECHNICAL GRADUATE, B. S. in M. E., age 24, single. Five and a half months' experience with conveyer manufacturer. Desires training with some engineering company. Salary secondary. Location, immaterial. Available at once. C-9095.

GRADUATE ELECTRICAL ENGINEER, 35, married. Twelve years' experience of which five as junior executive. Desires position as assistant general executive or in transmission or distribution department, United States. Street railway, power and light utility experience. Good references. Available July. C-5091.

ELECTRICAL ENGINEER, age 31, B. S. in E. E. Two years' electric car-shop experience; one year student engineer with power company; two years in engineering department of street railway company; one year electrical control of armament on aeroplanes; one year hydroelectric power studies. C-6077.

COMMUNICATION ENGINEER, 40, married, B. S., E. E. and E. E. degrees. Retired officer naval service. Twelve years' experience administration of communication organizations, development and operation radio-communication systems. Wide experience handling personnel. Three years director of radio, foreign government. Previous experience naval operator. Location, immaterial. Available July 1, 1931. C-9200.

ELECTRICAL ENGINEER, 34, married, graduated in Europe, with nine years' American experience covering drafting, testing, research, supervision of electrolysis work, operating and planning. Familiar with overhead and underground transmission and heavy electrical traction. Last two years as assistant electrical engineer with large hydro projects. Available on short notice. C-9170.

GRADUATE ELECTRICAL ENGINEER, desires substantial connection with public utility or industrial firm on power engineering as engineer or assistant to superintendent or engineer. Ten years' experience in power-plant test, operation, design, construction, and maintenance. Three years electrical engineer for industrial firm. Two years assistant to power engineer. B-8379.

ELECTRICAL ENGINEER, 35, married, B. S. in E. E., four years' experience in electrical design at steam and hydroelectric plants, switching stations, substations and transmission lines including field experience; two years design and construction of railway electrification. Also has had practical experience in industrial construction, factory and steel mill maintenance. References. C-9211.

SALES EXECUTIVE ENGINEER, electrical training and seven years' experience covering sales engineering, sales promotion, sales management. Has traveled extensively, acquainted with conditions in all sections of country. Well acquainted with New England. C-5431.

ELECTRICAL DESIGNER, age 36, married. Ten years' public utility experience in steam and hydroelectric plants, substations and industrial plants. Also served four years as fire insurance inspector. Graduate of technical school on electrical and mechanical subjects. C-7979.

ELECTRICAL ENGINEER, graduate, E. E. degree 1930, 25, American, single. Experience power-cable research and testing and allied work. Desires any kind of work in electrical engineering field. Best references. Available immediately. Any location considered. C-9188.

1930 GRADUATE OF E. E. under the cooperative plan at Georgia Tech. Worked alternate months with public utility company in Georgia in car-barn, gas, engineering, hydro-generation and statistics departments. Since graduation has worked six months with transmission line construction crew. Any location. C-9210.

ELECTRICAL ENGINEER, 30, married, university graduate, two years' experience distribution engineering for large electrical manufacturer; six years' experience power-plant and substation maintenance, operation, design, and construction with large power company. Wants position with power company, engineering, or construction firm. Available upon short notice. Will go anywhere. C-9267.

RADIO ENGINEER, 33, broad training in research, development and production of radio receivers, accessories, and component parts; responsible charge of quality; commercial understanding of engineering relations to purchasing and manufacturing; advertising and sales experience; resourceful. Available to progressive organization in radio or allied fields. B-5752.

EXPERIENCED TRANSLATOR, ELECTRICAL ENGINEER by profession, French and German, would prefer to translate technical and scientific books. Best of references. B-7091.

GRADUATE ELECTRICAL ENGINEER, 1930, 24, single. Seven months' experience transmission-line construction. Excellent physical condition. Desires position with future. Location preferred, East. C-9238.

ELECTRICAL ENGINEER, college graduate, over 20 years' experience in high-voltage transmission line and power-station work, principally with Siemens Schuckert and Brown Boveri companies in Germany. Desires responsible position. C-9257.

ELECTRICAL ENGINEER, 31, single, graduate University of California (1927), varied experience, designing, developing, testing high-frequency measuring apparatus. Has had some work engineering department, electrical manufacturing and radio concern. Desires connection with public utility, industrial equipment company. Now employed on development high-frequency apparatus. Location preferred, New York City. C-6734.

ENGINEER, college graduate with B. S. in E. E., seeks connection as chief engineer or superintendent of industrial plant or office building. Fifteen years' broad experience in power installation, operation and maintenance of electrical, mechanical and steam equipment. Familiar with building operation and maintenance. References furnished with interview. C-9262.

SWITCHBOARD FOREMAN, ten years' experience with construction companies for public utilities, wiring, construction and installation of powerhouse switchboards and control apparatus. Shop experience, manufacturing switchboards. C-4831.

SENIOR STUDENT in electrical engineering, graduating in June from Colorado University, available July first. Desires position as a junior engineer, sales engineer or instructor in mathematics or electrical engineering subjects. Has had 18 months' practical work in electrical service and repair of power equipment prior to college. Location preferred, Southern or Western United States. C-9241.

ENGINEER, graduate Stevens, one and one-half years' G. E. Test, with broad knowledge of transmission operation gained during five years with public utility operating in the foreign field; seeks new connection either domestic or foreign. Would be valuable for staff of general superintendent; mechanical engineer with electrical experience. C-9177.

GRADUATE ELECTRICAL ENGINEER, 1929, age 24, single. Two years' experience in overhead distribution and transmission design, drafting, and estimating. Best of references. C-9256.

ELECTRICAL AND RADIO ENGINEER, 39, University graduate with B. S. in E. E. G. E. Test experience. Fifteen years in design, test and operation of radio and high-frequency circuits and apparatus. Married, two children. Location secondary importance, West preferred. Available immediately. C-9246-314-C-12-San Francisco.

GRADUATE ELECTRICAL ENGINEER, age 25. Two years' experience in power system operation, system planning and development; also experience in distribution and transmission engineering. Desires position in any location with public utility, or in any electrical line offering a future. Available upon short notice. References. C-9281.

RADIO ENGINEER, 35, married, A. B. in M. E., and Engineer in E. E. Fourteen years' experience, research, development, design, installation, and testing of radio transmitting equipment. Also experienced, patent investigations, office management, and purchasing of materials. Desires executive, research, or teaching position permitting advancement of art of radio communication. C-9251.

ELECTRICAL, MECHANICAL, CONSTRUCTION ENGINEER, 35, married. Experience in installation of automatic equipment in power stations, general construction about 11 years. Has five years air-corps service. Available upon notification. Location preferred, San Francisco, California. C-9247-314-C-15-San Francisco.

GRADUATE ELECTRICAL ENGINEER, 23, B. S., M. S. in E. E. Desires position, instructor in engineering department of college, university. Has fundamental, practical knowledge d-c., a-c. circuits and machines. Can teach engineering mathematics, physics. Has had some teaching experience; two years research work obtaining degrees. Available July 1st. Location, anywhere United States. C-9214

GRADUATE ELECTRICAL ENGINEER, 29, one year Westinghouse Test course, six years engineering for large eastern utility. Familiar design, construction, and operation of distribution substations, customers' services, load dispatching and supervisory-control system. Desires responsible position with public utility, consulting engineers, or sales work with electrical manufacturer. C-8322.

RELAY ENGINEER, university graduate, ten years' practical experience, thoroughly familiar with all relay applications and testing, short-circuit studies, stability calculations, and all problems connected with system disturbances. Moderate salary. Available at once. C-9291.

ELECTRICAL ENGINEER, 25, married, desires engineering work. Has been on electrical seismograph for last two years. Work involved use of portable oscillograph and wireless telegraphy. Holds second-grade commercial operator's license. Has one year public utility experience and surveying experience. Personal interview desired. C-3035.

ELECTRICAL ENGINEER, 23, single, graduate Georgia School of Technology, B. S. degree in E. E. Cooperative plan 1930; five years' experience railroad shop all departments during cooperative course; one year experience with utility on manufacturing concern. Prefers Southeast. C-9292.

DISTRIBUTION ENGINEER, 29, single. Six years' experience on overhead distribution, estimating, design, construction and revamp in general office of large utility. Available immediately. Location preferred, West, but will consider others including foreign country. C-9307-314-C-13-San Francisco.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.	205 West Wacker Drive	31 West 39th St.
San Francisco	Chicago	New York
N. D. Cook, Manager	A. K. Krauser, Manager	W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

JUNIOR ENGINEER, 1930, graduate, B. S. degree in E. E. Associate member of Sigma Xi. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

ELECTRICAL ENGINEER, age 28; single; considerable industrial experience; one year as graduate assistant; M. S., Iowa State College, 1930; B. S. Pennsylvania State College, 1925. Desires position as instructor with the prospect of a permanent teaching position. C-3202.

ELECTRICAL ENGINEER, 28, A. B., E. E. 1926. Two years as emergency man, one year as engineering assistant with a New York Power Company. Four years with a Telephone Company making studies of equipment and operating conditions and on service maintenance. Two years teaching mathematics in evening classes. References. C-9308.

HEATING ENGINEER, 12 years' experience, largely on industrial electric heating equipment, particularly heat treating and forging furnaces. University of Wisconsin graduate (1918). Some arc-welding and motor design experience. Familiar with research, design and sales practise. Locate anywhere. Prefer executive position. B-8838.

ELECTRICAL ENGINEER, B. S. degree in E. E. in 1925. Five years' experience in electrical equipment design, public utility operation, and field construction. Natural writing talent. Desire work in editorial or related fields. C-4875.

RADIO ENGINEERING GRADUATE, student in one of the greatest eastern universities, desires connections fitting his education. Has B. E. degree in E. E. and has been very active in radio engineering practise for seven years. Available at once, age 23 years. C-7315.

GRADUATE IN ELECTRICAL ENGINEERING, 1928, married; one year's experience on Westinghouse test floors assigned to traction apparatus. Has completed Westinghouse graduate student course. Has had approximately 18 months' experience as sales engineer. Especially interested in work within transportation industry, or as instructor in recognized engineering school. Excellent scholastic record and references. C-9309.

GRADUATE ELECTRICAL ENGINEER, 35, good technical school. Ten years' experience in electrical station construction and design drafting, including considerable mechanical experience. Latest position superintendent of design and construction of transformer substation. Preferring station design and construction with utility, would consider engineering industrial plant maintenance or operation. C-7043.

COLLEGE GRADUATE class of '29, B. S. degree in electrical engineering, 25, single, G. E. Test, general engineering and business courses. Interested in position in engineering department of manufacturing or utility company. Available at once. Location, Eastern United States. C-9003.

ELECTRICAL-MECHANICAL ENGINEER, 28 years old, experienced in power generation, distribution and application to industrial uses. Desires position as electrical-mechanical engineer in charge of operation, maintenance and repairs with manufacturing concern generating own power. C-9063.

GRADUATE ELECTRICAL ENGINEER with broad experience in development and design, executive and engineering on small electric motors, desires connections as engineer or chief draftsman. Available in from twenty to thirty days. Married. References. B-9395.

COLLEGE GRADUATE, 27, single, B. S. in E. E. Eighteen months General Electric Test, twenty-two months telephone equipment engineer. Desires position in manufacturing or utility company. Location preferred, Middle West, but, not essential. Available at once. C-9285.

ELECTRICAL ENGINEER, B. S. degree 1929, married, 33, American. Two years' experience as a draftsman-designer with large utility company. Experienced on outdoor and indoor high-voltage substations. Speaks Russian, (United States citizen). Well acquainted with Manchuria, China. Location, immaterial. C-6290.

ESTIMATING ENGINEER, B. S. degree in E. E., age 34, married. Ten years' experience with large company manufacturing electrical power equipment, including designing electrical and mechanical construction and calculating cost, weight and dimensions of this apparatus, in connection with customers' negotiations. Available at once. Location, immaterial. C-4633.

GRADUATE ELECTRICAL ENGINEER, single, age 25, eight months engineering assistant power department office of public utility, fourteen months equipment engineer handling installation and testing of toll line telephone equipment. Good general knowledge of building trades. Excellent references. Location, immaterial. C-8126.

ELECTRICAL ENGINEER, 24, single; B. S. in E. E., 1929; M. S. 1931. Westinghouse graduate student course. Some experience in acoustic and radio laboratories. Six months' experience with phototube and grid-glow tube applications. Natural writing ability. Available at once. Location, immaterial. C-9314.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, age 24 and single. Experience in machine shop and steel construction work. Four years of practical and theoretical electricity in college. Willing to start at bottom and work up with a reliable company. Available any time. Location, anywhere in United States. C-9135.

ELECTRICAL ENGINEER, age 45, technical school graduate desires position with railway, consulting engineer, or industrial plant. Twenty-four years' experience with large street railway and electrical contractor on drafting, designing, estimating, construction and operation of power, distribution and miscellaneous electrical. Conversant with power reports, new projects, budgets and executive responsibility. C-7202.

ELECTRICAL ENGINEER, 1930 graduate, 22, single. One year on the Westinghouse student course. Desires position as instructor in electrical engineering. Available school year 1931-1932. References. Location, immaterial. C-9311.

ELECTRICAL ENGINEER, B. S. E. E., '29, M. S. E. E. '31, leading university, 18 months General Electric Test, 23, single. Desires to teach in technical university. Prefer Mid West. C-9320.

ELECTRICAL ENGINEER with Master's degree, industrial design and development of electrical-control equipment, authority on electrolytic condensers; married; will work anywhere except Russia. Available on six weeks' notice. Employed at present. Not interested in position without full responsibility. C-7288.

ELECTRICAL EXECUTIVE, 39, married. Thoroughly experienced in power plant and industrial construction, maintenance. Can handle men and improve service. Very well qualified to assume part of the responsibility of a busy executive. Replies confidential. C-2028.

ELECTRICAL ENGINEER for eight years in charge of design and construction of large switching stations up to 220,000 volts in the East, and with strong mechanical and structural antecedents seeks permanent connection. C-9332.

Membership

Recommended for Transfer

The Institute's board of examiners at its meeting of April 29, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

KELLY, MERVIN J., Vacuum Tube Development Engr., Bell Telephone Laboratories, Inc., New York.
KRAFT, CHRISTOPHER H., Supt. of Electrical Distribution, Union Electric Light and Power Co., St. Louis, Mo.

To Grade of Member

AJANI, FRANCESCO, vice-director, Societa Industrie Elettrotelefoniche, Turin, Italy.
ALLENDE, OCTAVIO E., asst. general mgr., Compania Electrica de Cartago, Costa Rica, C. A.
CARTER, E. L., consulting engr., 814 Continental Bank Bldg., Indianapolis, Ind.
COOPER ROBERT S., supervisor of communications, West Penn Power Co., Connellsville, Pa.
CORSON, LeROY, supervisor, N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
FEDER, TOBIAS M., district sales mgr., Jeffery Dewitt Insulator Co., Chicago, Ill.
GOLDTHWAITE, GEORGE E., consulting engr., Hine, Goldthwaite & Mylott, New York.
MARQUIS, VERNON M., elec. engr., American Gas & Elec. Co., New York.
MARTIN, EDWIN R., motor engr., Delco Products Corp., Dayton, Ohio.
RALPH, ARTHUR J., technician, Yale University, New Haven, Conn.
ROTTY, OSCAR J., supt. of substations, Union Electric Lt. & Pr. Co., St. Louis, Mo.
SANO, SHIRO, president, Sano Electric Mfg. Co., Tokyo, Japan.
SCHULER, L. R., inspector, Public Service Co. of Northern Illinois, Chicago, Ill.
WRIGHT, SUMNER B., telephone engr., American Tel. & Tel. Co., New York.

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before June 30, 1931.

Atkinson, C. R., General Electric Co., Fort Wayne, Ind.
Bailey, R. S., (Member), American Tel. & Tel. Co., New York, N. Y.
Balzer, E. W., Healds Engineering College, San Francisco, Calif.
Bangs, J. E., (Member), Suite 1122, Earle Bldg., Washington, D. C.
Bardwell, M. W., Syracuse Lighting Co., Inc., Syracuse, N. Y.
Barkson, J. A., American Tel. & Tel. Co., Cleveland, Ohio
Bonnett, A. A., Alaska Gold Mines Co., Thane, Alaska
Boulton, B. K., (Member), Beauharnois Construction, Beauharnois, Que., Can.
Buese, L. A., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Burleson, W. H., (Member), Ohio Brass Co., Mansfield, Ohio
Campbell, R. W., General Electric Co., New York, N. Y.
Clark, Maurice E., New England Tel. & Tel. Co., Boston, Mass.
Elliott, H. J., Atmospheric Nitrogen Co., Hopewell, Va.
Fouracre, V. W. M., M. Montgomery & Co., Ltd., Vancouver, B. C., Can.
Friedman, V. N., (Member), Jas. R. Kearney Corp., St. Louis, Mo.
Gills, E. T., Ohio Brass Co., Mansfield, Ohio
Gonzalez, J. J., Veracruz Electric Lt. Pr. & Traction Ltd., Veracruz, Mexico
Harris, C. E., Duke Power Co., Charlotte, No. Car.
Hatfield, B. F., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Herwegh, L. J., (Member), Atwater Kent Mfg. Co., Philadelphia, Pa.
Holmes, L. O., Rensselaer Polytechnic Institute, Troy, N. Y.
Hutson, R. V., Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio
Ingles, J. A., Hydro-Electric Power Commission of Ontario, Toronto, Ont., Can.
Jack, F. M., New York Edison Co., New York, N. Y.
Kalen, E. T., N. W. Electric & Machine Co., Milwaukee, Wis.
Kanekeberg, A., Public Service Co. of Colo., Denver, Colo.
Kiltie, O., General Electric Co., Fort Wayne, Ind.
Kimbrell, M. R., (Member), Duke Power Co., Charlotte, No. Car.
Lyons, S. E., D. L. & W. Railroad Co., Hoboken, N. J.
May, D. M., Collins Flashlight Corp., New York, N. Y.
McGuire, F. J., Otis Elevator Co., Yonkers, N. Y.
Morgan, F. D., Allied Engineers, Inc., Jackson, Mich.
Morris, F., Saskatchewan Power Commission, Moose Jaw, Sask., Can.
Muller, H. S., New Jersey Bell Tel. Co., Newark, N. J.
Myers, C. F., Puget Sound Power & Light Co., Wenatchee, Wash.
Needham, G. H., New Jersey Bell Tel. Co., Newark, N. J.
Organ, J. W., Union Electric Light & Power Co., St. Louis, Mo.
Peterson, A. W., Continental Electric Co., Inc., Newark, N. J.
Peterson, N. T., MacMillen Elec. & Mfg. Co., Los Angeles, Calif.
Powell, J. A., (Member), W. S. Barstow & Co., Inc., Reading, Pa.
Rogers, T. A., University of California, Berkeley, Calif.
Russell, H. G., 37 Harvard St., Worcester, Mass.
Slezak, S. T., New York Telephone Co., New York, N. Y.
Warrington, A. R., General Electric Co., Philadelphia, Pa.
44 Domestic

Foreign

Gara, E., Chile Exploration Co., Chuquicamata, Chile, So. America
Hofman, S. P., The General Electric Co., Ltd., Witton, Birmingham, Eng.
Kempe, R., Asea, Ludvika, Sweden
Robinson, C. S., Cia. Chilena de Electricidad Ltd., Santiago, Chile, So. America
Singh, G., Mussoorie Hydro-Electric Scheme, Dehradun, U. P., India
Stock, J. M., Cia. Interprovincial de Servicios Publicos S. A., Buenos Aires, Argentina, So. America
Texier, J., M. M. Schneider & Cie, Paris, France
van Dyk, J., Philips Lamps (A'sia) Ltd., Sydney, N. S. W., Australia
8 Foreign

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during April are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Electrical Drafting and Design. 2nd edit. By C. C. Bishop. N. Y., McGraw-Hill Book Co., 1931. 190 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $2.00.——Covers the ordinary work done in the office of an engineer, contractor or power company, in drafting and designing layouts, switchboards, residence and power wiring, etc. A collection of tables is included. The book bridges the gap between the usual course in mechanical drawing and the practical methods of the industry. The new edition has been revised to meet changes in underwriters' rules and in apparatus.

Grundwasser-Abdichtung. 3. Auflage. By J. Schultze and W. Sichardt. Berlin, W. Ernst u. Sohn, 1931. 69 pp., illus., diagrs., tables, 10 x 7 in., paper. 5-r. m.——A concise review of practical methods for waterproofing mortar and concrete in underground structures. The advantages and disadvantages of different methods are described and directions given for their use.

Grundzüge der Technische Schwingungslehre. By O. Föppl. Berlin, J. Springer, 1931. 212 pp., illus., diagrs., tables, 8 x 5 in., cloth. 9.50-r. m.——2nd edit. A concise treatise on the theory of vibration and its applications in engineering. The effects of vibration upon structural materials, methods of calculating frequencies, damping devices, the prevention of vibration in reciprocating machines, and similar topics are discussed.

High Frequency Alternating Currents. By K. McIlwain and J. G. Brainerd. N. Y., John Wiley & Sons, 1931. 510 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth. $6.00.——A course for senior students, as given at the University of Pennsylvania. The theory of these currents is presented and their use in telephony, radio communication, remote control, and other purposes are discussed.

High-Speed Diesel Engines. By A. H. Goldingham. Lond., E. & F. N. Spon, Ltd., 1931. 148 pp., illus., diagrs., charts, tables, 9 x 6 in., 10s. 6d.——After an introductory chapter upon the theory and advantages of this engine, the various systems of fuel injection are described in detail. The remaining two-thirds of the book describes various types of high-speed Diesel engines. The book summarizes the present position of this engine in convenient form.

"Hütte" des Ingenieurs Taschenbuch. 26 Auflage, 1 Band, 1931. By Akademische Verein Hütte. Berlin, W. Ernst u. Sohn, 1931. 1199 pp., diagrs., charts, tables, 8 x 5 in., cloth, 17,50 r. m.; leather, 20,50 r. m.——The first volume of the new edition covers such fundamental matters as mathematics, mechanics, technical physics, heat, strength of materials, materials, measurements and surveying. Compared with the previous edition, this is ten per cent larger and has been thoroughly revised throughout. Hütte still remains the most comprehensive collection of engineering tables, formulas and general information in print.

Mathematical Tables and Formulas. By R. D. Carmichael and E. R. Smith. Bost. & N. Y., Ginn & Co., 1931. 269 pp., diagrs., tables, 9 x 6 in., cloth. $2.00.——This compilation aims to meet the needs of students in mathematics courses and other courses that require mathematical computations or involve mathematical processes. It contains the usual logarithmic and trigonometric tables, up to five places, needed in the study of college algebra and trigonometry; other numerical tables frequently used in computation; and a collection of mathematical formulas, integrals and series.

Modern Diesel Engine Practice. By O. Adams. N. Y., Norman W. Henley Publ. Co., 1931. 656 pp., illus., diagrs., tables, 10 x 6 in., cloth. $6.00.——A descriptive work, intended primarily for the operating engineer and the owner. Special attention is given to applications of Diesel engines, and to operating and maintenance practise. Aircraft engines and locomotives are included.

Non-Interpolating Logarithms, Cologarithms and Antilogarithms. By Frederick W. Johnson. San Francisco, Simplified Series Publ. Co., 1930. 23 pp., tables, 9 x 6 in., limp cloth, note-book edit. $1.60; fabrikoid, $2.25; full leather, $4.00——Four-place and five-place logarithms and antilogarithms, and four-place cologarithms can be obtained from these tables by inspection, without any calculation. The tables are very compactly printed, in clear type, on substantial paper, and are thumb indexed. Additional tables of constants, metric conversion factors and other frequently used data are included.

Pocket-Book of Electrical Rules and Tables. By W. R. Cooper and R. Appleyard. Phila., J. B. Lippincott, 1931. 765 pp., illus., diagrs., tables, 7 x 4 in., cloth. $4.00.——A reference book giving special attention to electrical instruments and measurements, conductors, submarine cables, telephony and radio, but also treating more briefly of electrometallurgy, dynamos, balancers, transformers, power-factor improvement and illumination. The book has long been valued by cable and telegraph engineers as a practical pocketbook. Various specialists have contributed to the revised edition.

Radio Handbook, including Television and Sound Motion Pictures. By J. A. Moyer and J. F. Wostrel. N. Y., McGraw-Hill Book Co., 1931. 886 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth. $5.00.——A concise but comprehensive reference book for the radio engineer. The authors have summarized the existing data upon radio apparatus, not only for telephony and telegraphy, but also for industrial power control and similar purposes.

Radioelements and Isotopes: Chemical Forces and Optical Properties of Substances. By K. Fajans. N. Y., McGraw-Hill Book Co., 1931. 125 pp., diagrs., charts, tables, 9 x 6 in., cloth. $2.50.——A review of the researches of the author and others upon the nature of chemical forces and the relation of these forces to the optical properties of atomic and crystal structures. The book is based upon the author's lectures at Cornell University during 1930.

S. A. E. Handbook. 1931 edit. Society of Automotive Engineers, N. Y. 752 pp., diagrs., charts, tables, 8 x 4 in., cloth. $5.00 to non-members.——Contains the standards and recommended practises of the Society, revised to March, 1931.

Standard Wiring for Electric Light and Power, 1931. By H. C. Cushing, Jr. Publ. by H. C. Cushing, Jr., N. Y., 1931. 503 pp., illus., diagrs., tables, 7 x 4 in., leather, $3.00.——The new edition of this well-known handbook has been thoroughly revised to represent the latest approved practise. Specific directions are given for wiring for all ordinary purposes, for installing motors, generators and storage batteries, and for lighting.

Vergrösserung der Effektiven Höhe von Flugzeugschleppantennen. (Luftfahrtforschung Bd. 8, s. 141-154, Heft 6, 3 März 1931.) By F. Eisner, G. Sudeck, R. Schröer and O. Zinke. München, R. Oldenbourg, 1931. Illus., diagrs., tables, 12 x 8 in., paper, 2,80 r. m. ——Reports the results of an investigation of the efficiency of trailing antennas for aircraft radio stations and describes an improved L-shaped antenna.

List of Alloys with Physical Properties of Typical Alloys. By W. Campbell. Phila., American Society for Testing Materials, 1930. 65 pp., 9 x 6 in., paper, $1.50; cloth, $2.00. Over 2,500 alloys are represented. These are mostly non-ferrous alloys, but certain non-corrosive and heat-resistant iron alloys are included. The composition of each alloy is given and, in some cases, the physical properties.

Personnel Problems. Methods of Analysis and Control. By F. E. Baridon and E. H. Loomis. N. Y., McGraw-Hill Book Co., 1931. 452 pp., diagrs., charts, tables, 9 x 6 in., cloth. $5.00.——Intended as guide in the study and solution of these problems. The questions that constantly arise under modern industrial conditions are outlined specifically, and methods for their analysis and control are suggested.

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(June 1931) Number	Author	Title
☐ 31-1	William B. Blanton	A Printing Telegraph Concentrator
☐ 31-15	Charles Kerr, Jr	Motive Power for Suburban Electrification
☐ 31-16	Samuel Martin, Jr	Electric Resistance Brazing
☐ 31-31	F. Creedy	The Neutralized Welder—A Means of Controlling Transients
☐ 31-33	C. Richard Soderberg	Heat Losses in Large Turbine-Generators
☐ 31-38	G. M. Little	The Application of the Helical Groove to Slip-Rings and Commutators
☐ 31-48	H. E. Edgerton and Paul Fourmarier	The Pulling Into Step of a Salient-Pole Synchronous Motor
☐ 31-55	R. M. Stanley and C. T. Sinclair	The Primary Network
☐ 31-59	R. D. Evans and S. H. Wright	Power System Voltages and Currents Under Fault Conditions
☐ 31-61	W. A. Lewis and L. S. Tippet	Fundamental Basis for Distance Relaying on Three-Phase Systems
☐ 31-65	R. L. Young and R. L. Lunsford	Automatic Power Plants for Telephone Offices

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its publication in Electrical Engineering. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name..

Address..

Please order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Selected Items From

Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translation of foreign articles at cost.

Boilers

ELECTRIC. Packed Heat from a New Type of Electric Steam Generator, H. Bidwell and L. H. Jones. *Indus. and Eng. Chem.*, vol. 23, no. 3, Mar. 1931, pp. 298-300, 2 figs. Description of generator suitable for hospital sterilizers, pressure cooking retorts or industrial processes where large amount of steam is required for short time which has reservoir properly located between high- and low-water levels which serves as source of energy, so that pressure from boiler is immediately available when required.

Cables

FAULT LOCATION. Service d'études et de recherches techniques (Study of Underground Conductors and their Failures). *Annales des Postes Télégraphes et Téléphones*, vol. 20, no. 2, Feb. 1931, pp. 153-160, 8 figs. By running telephone frequencies through cable and by using loop operated amplifier, course of cable or of single conductor in group of conductors and various types of faults and insulation troubles can be detected.

HIGH TENSION. Elektrische Arbeitsuebertragung durch Hochspannungskabel (Electric Power Transmission Through High-Voltage Cables), J. Kuehle. *Elektrotechnische Zeit.*, vol. 52, no. 12, Mar. 19, 1931, pp. 373-377, 15 figs. Comparison between operating characteristics of cable and overhead lines; advantages and disadvantages of both systems shown by numerical comparison; three-conductor and single-conductor cables in three-phase system; lead sheath losses and process in dielectrics.

LEAD SHEATHING. Kristallgefuege und Disglomeration des Bleies (Crystaline Structure and Disglomeration of Lead), O. Haehnel. *Elektrische Nachrichten Technik*, vol. 8, no. 2, Feb. 1931, pp. 77-88, 16 figs. Metallographic measurement of crystallite grain of pure lead yield mean diameter of 8 mm. being largest crystallites which ever have been observed in cast lead cooled in manner as described; all lead drawn from cable lead presses has much smaller crystallites; grain in cable press is determined by operating temperature and working pressure.

METAL SHEATHED. De la préférence à donner aux alliages plomb-antimoine, plomb-antimoine cadmium sur le plomb pur dans la fabrication des gaines de cables électriques et téléphoniques (Superiority of Lead-Antimony, Lead-Antimony-Cadmium over Pure Lead in Manufacture of Sheathing for Electric and Telephone Cables), H. Godin. *Revue Universelle des Mines*, vol. 5, no. 4, Feb. 15, 1931, pp. 106-109, 1 fig. Failure of cable sheaths without apparent cause; results of analyses of failure by Archbutt and Radwdon; means of avoiding intercrystalline failures of cable sheaths.

POTHEADS. Die bisherige Entwicklung der Kabelendverschluesse ohne Vergussmasse (Present Development of Cable Potheads Without Dilling Compound), E. Eule. *Siemens Zeit.*, vol. 11, no. 2, Feb. 1931, pp. 95-102, 20 figs. Equipment of Siemens and Schuckert, its features, application and installation are described.

STANDARDS. Standard Color Code for Control Cable, G. Sutherland. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 413-414. Color scheme prepared by joint committee of N.E.L.A. and N.E.M.A. following extensive review of questionnaires sent to 26 leading American utility companies and survey of field tests conducted by joint committee; standard color scheme table for control cable.

TELEPHONE—LIGHTNING. Blitzschlaege in Fernkabelanlagen (Lightning Strokes in Long Distance Telephone Cables), P. Kleinsteuber. *Telegraphen und Fernsprech Technik*, vol. 20, no. 2, Feb. 1931, pp. 48-50, 5 figs. Various typical cases and their analysis.

Circuit Breakers

OIL. New Ironclad Switchgear. *Engineer*, vol. 151, no. 3925, Apr. 3, 1931, p. 386, 2 figs. Following success of "T A P" circuit breaker by Crompton-Parkinson, Ltd., of Chelmsford, firm has designed metal-clad oil circuit breaker on somewhat similar lines; unit is made for currents up to 300 amperes at 3,300 volts, or 600 amperes at 650 volts for three- or four-wire circuits, and can be used singly or number of units can be made to form switchboard.

Circuits

VECTOR ANALYSIS. Mechanical Aids in the Construction of Vector Diagrams, B. S. Willis. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 224-227, 6 figs. Numerical solutions combined with graphical representations; various examples from electric circuit practise are given.

Compensators

Détermination d'un groupe formé par un transformateur à trois enroulements et un compensateur synchrone (Determination of System Formed by Three Winding Transformer and Synchronous Compensator), F. Hallopeau. *Revue Générale de l'Electricité*, vol. 29, no. 9, Feb. 28, 1931, pp. 338-348, 9 figs. Power calculation of compensator connected to network by means of transformer as outlined; mathematical and graphical solution; vector diagrams of transformer.

Condensers

STATIC. Les condensateurs statiques et l'amélioration du facteur de puissance (Static Condensers and Improvements of Power Factor), *Science et Industrie*, vol. 15, no. 205, Feb. 1931, pp. 88-92, 11 figs. Problem; electric rates; determination of corrective capacity in kva. for given installation; various solutions; comparison between condensers and synchronous motors; electric condenser as accepted electric equipment.

TESTING. Bemerkungen zur Pruefung von Kondensator-Durchfuehrungen (Remarks on Testing of Condenser Bushings), L. Kumlik. *Elektrizitaetswirtschaft*, vol. 30, no. 6, Mar. 1931, pp. 171-172. Manufacture is started by other hard paper plants since exhaustion of Nagel patents; as these have no previous experience critical analysis is given of usual testing method from which conclusions may be drawn as to quality of product.

Conduits

UNDERGROUND. Expérience d'un nouveau procédé de construction des conduites multitubularies sans joint (Test of New Process of Construction of Multi-Duct Jointless Conduits), M. Moine and L. Daumard. *Annales des Postes Télégraphes et Téléphones*, vol. 20, no. 3, Mar. 1931, pp. 178-192, 12 figs. Description of Oravetto design, tested in Nice, France; design calls for reinforced-concrete monolith blocks containing as many as 12 parallel circular ducts 10 cm. in diameter.

Contactors

A Periodic Contactor Operated by a Neon-Tube Oscillator, H. J. Reich. *Rev. Sci. Instruments*, vol. 2, no. 3, Mar. 1931, pp. 164-170, 5 figs. Simple device, capable of closing circuit periodically at any desired frequency and holding it close for any desired fraction of cycle, finds frequent use as laboratory or lecture demonstration apparatus; writer had occasion to design such instrument, in which timing device was neon-tube oscillator; reliability and general usefulness of this device during almost year; design and constructional details.

Discharge

ELECTRODELESS. Sur un nouvel aspect de la décharge en haute fréquence (New Phenomenon in Electrodeless Discharge), M. Chenot. *Académie des Sciences—Comptes Rendus*, vol. 192, no. 1, Jan. 5, 1931, pp. 38-40; see also brief translated abstract in *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, p. 166. Experiments in electrodeless discharge obtained with 3.4-m. waves led to appearance of series of stationary waves which indicate wave propagation along tube at velocity between 3 and 5 per cent of velocity of light; author had previously suggested that long-delay radio echoes may be due to such propagation at greatly reduced velocities.

Education

ENGINEERING. Report of 1930 Survey of Engineering Education, F. L. Bishop. *Jl. Eng. Education*, vol. 21, no. 7, Mar. 1931, pp. 1-77. Survey to secure measure of progress which had been made in engineering education in each institution.

Electric Drive

ROLLING MILLS. Large Rolling Mill Motor. *Elec. Times*, vol. 79, no. 2056, Mar. 19, 1931, p. 527, 2 figs. At present time there is large rolling mill motor on test bed at Stafford works of English Electric Co., for replacing existing steam engine driving 27-in. three-stand reversing mill at Brown Bayley's Sheffield works; it operates on form of Ward-Leonard Ilgner system and comprises main driving motor, flywheel motor generator set, three exciters, slip regulator and necessary control; continuous r. m. s. capacity b.hp. at 30 r. p. m. is 1980; speed range at constant torque, r. p. m. is plus minus 0/30; speed range at reduced torque, r. p. m. is plus 30/70; armature, volts is 536.

PAPER AND PULP MILLS. Synchronous Motors in the Paper Industry, D. R. Shoults. *Paper Trade Jl.*, vol. 92, no. 13, Mar. 26, 1931, pp. 47-50, 3 figs. Advantageous features of synchronous motor drive in paper industry; Korndorffer method; automatic control; pulp grinder drives; Jordon and beater drives; pumps, air compressors and screens; chipper drive. Before Tech. Assn. of Pulp and Paper Industry. See similar article by author, "Electrical Developments," previously indexed from Paper Mill, Jan. 3, 1931, under heading, Paper and Pulp Mills—Electric Equipment.

Electric Lines

HIGH TENSION GROUNDING. Umfassende Erdungsanlage in eimen 380/220 V Verteilnetz (Extensive Grounding Installation in 380/220 Volt Distribution Network), C. Richard. *Assn. Suisse des Electriciens—Bul.* vol. 22, no. 7, Apr. 3, 1931, pp. 166-170, 10 figs. Possibilities available for decrease of ground voltage in case of disturbance; method applied to this purpose in Bassecourt, control test by which it was shown that for all cases of grounding no ground voltages over 50 kv. occurred.

RELAYS. Theory and Application of Relay Systems Low Voltage Transmission Lines—I, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 231-237, 17 figs. Three principal types of low-voltage circuits, namely, radial, parallel feeder, and loop systems each require different scheme of relay protection; no detailed study of short-circuit values is ordinarily required for simple radial system, and ordinary over-current relays may be used; with parallel feeders, selective-differential current relays can be applied at generating station end of line, and at substation end, directional over-current relays may be applied; application of relays to loop systems; selective timing of relays.

RURAL — LIGHTNING. La protection contre la foudre des réseaux de distribution d'énergie électrique à basse tension (Protection Against Lightning of Low Voltage Electric Power Distribution Networks), C. Ledoux. *Revue Générale de l'Electricité*, vol. 29, no. 12, Mar. 21, 1931, pp. 467-476, 10 figs. Results of recent investigation have shown that with increasing rural electrification, number of cases of lightning stroke have actually increased; Dauzére together with author have traced relation between geological nature of soil and frequency with which strokes occur; solutions proposed by P. Juppont and C. Dauzére are examined.

Electrolytes

Les Electrolytes Forts (Strong Electrolytes), R. Dufour. *Societe Francaise des Electriciens—Bul.*, vol. 1, no. 2, Feb. 1931, pp. 128-139, 1 fig. Consequences of theory of Debye with regard to conductibility are set forth.

Elevators

ELECTRIC. Elevator Installation and the General Building Contractor. *Gen. Bldg. Contractor*, vol. 2, no. 3, Mar. 1931; pp. 61-68, 6 figs. Method for computing elevator requirements;

typical elevator layout with overhead machinery; power panel and sizes of conduits; parts and devices that may have to be installed on modern high-speed elevator; tabulation of items.

DESIGN. Tells of Elevator Engineering Progress, J. Sozansky. *Power House*, vol. 25, no. 3, Mar. 1931, p. 52. Historical review of electric elevator developments; self-leveling type; operatorless cars; wasted rentable space. Before Montreal District Engins.' Assn.

Frequency

MEASUREMENTS. Ueber die Messung sehr kleiner Frequenzen und ihre Anwendung fuer Fernmessungen (Measurements of Very Low Frequencies and Their Application for Remote Measurement), E. Hudec. *Elektrotechnische Zeit.*, vol. 52, no. 12, Mar. 19, 1931, pp. 380-385, 10 figs. Impulse frequency method; use of ballistic instruments; generation of nearly constant current by means of condenser choke arrangement; decreasing crest intervals through repeated smoothening; repeated switching of short-circuited cable, use of filters, etc.

Furnaces

ANNEALING. Electrically Heated Annealing Furnaces, J. C. Woodson. *Heat Treating and Forging*, vol. 17, no. 3, Mar. 1931, pp. 285-288 and 291, 7 figs. Progress in design and application of annealing furnaces for ferrous and non-ferrous metals; economies for casting annealing runs from 8 to 15 lb. per kw-hr.; temperatures range from 950 to 1,650 deg. fahr., for carbon steel and to 1,950 deg. fahr. for manganese steel.

CALCIUM CARBIDE. La nouvelle usine à carbure et cyanamide de wingles (New Carbid and Cyanamide Plant of Wingles), R. Sevin. *Jl. du Four Electriques*, vol. 40, no. 2, Feb. 1931, pp. 51-58, 10 figs. List of plants in Europe and United States giving types and capacity of electric furnaces; detailed description ,of plant of Société des Mines de Lens, containing 2 lime kilns of 60 tons; carbide plant and 2 Miquet electric furnaces of 6,000 kw.; and their control.

INDUCTION. Tonnage Melting by Coreless Induction, E. F. Northrup. *Fuels and Furnaces*, vol. 9, no. 4, Apr. 1931, pp. 473-478, 7 figs. First of series covering fundamental principles of operation and construction of coreless induction furnace as applied to tonnage melting; development of high-frequency coreless-induction furnace; power requirements and sizes of furnaces and features of construction. (To be continued.)

MELTING. The Russ Induction Furnace. *Engineering*, vol. 131, no. 3404, Apr. 10, 1931, p. 497, 3 figs. Furnace manufactured by Industrie Elektro-Ofen G. m. b. H., Cologne, has normal capacity of 600 kg. and is capable of dealing with all types of non-ferrous metals; important feature is that furnace can be supplied from ordinary mains through Scott-connected transformer.

REFRACTORY MATERIALS. Refractory Materials for Electric Furnaces—I, A. B. Searle. *Metal Industry* (*Lond.*), vol. 38, no. 13, Mar. 27, 1931, pp. 333-335. Copper and its alloys, including bronze, gun metal, brass, copper-nickel, and phosphor-bronze; refining furnaces; lining; use of magnesia; bricks for lining; crucibles; roof; annealing furnaces.

Fuses

HIGH TENSION. Die neue Hockspannungs-Hochleistungsicherung (H-H-Sicherung) der SSW (New High Tension High Capacity Fuse of Siemens Shuckert Company-(H. H. Type Fuse), H. Laepple. *Siemens Zeit.*, vol. 11, no. 2, Feb. 1931, pp. 65-70, 9 figs. New design of which fusing capacity is so high that they may be applied directly for short circuit protection of transformers and line taps, without use of reactors or resistances.

Generators

AUTOMOBILES. Electric Lighting Equipment, H. Cousins. *Automobile Engr.*, vol. 21, no. 278, Mar. 1931, pp. 100-106, 26 figs. Design and operation of various types of dynamos; functioning of regulators with particular regard to consideration of service requirements and reliability; diagrams illustrate C.A.V., Scintilla, and Bosch compensated voltage control system.

COILS. The Importance of Accurately Wound Field Coils, J. C. de la Rosa. *Elec. News*, vol. 40, no. 6, Mar. 15, 1931, pp. 57-58, 1 fig. By rewinding each of 12 field coils of rotary to standard equivalent resistance sparking was completely eliminated.

Heating

Industrial Applications of Electric Heat, L. M. Jenks. *Elec. Specifications*, vol. 3, no. 4, Apr. 1931, pp. 12-13, and 45, 4 figs. Last 10 years have brought development and perfection of so many new and unusual electric heating devices that it seems nothing is impossible; primarily, it may be said that electricity makes better product at lower cost; labor item should receive special consideration where product is to be machined or polished after heating process.

BUILDINGS. The Electric Heating of Buildings. *Engineering*, vol. 131, no. 3402, Mar. 27, 1931, p. 415. Review of two papers read before Institution of Civil Engineers and Institution of Electrical Engineers, respectively; first, by S. M. Saunders and W. L. Swale, describes results obtained from electric thermal storage as applied to building heating; includes list of 22 such installations in Great Britain; second paper, by T. J. Illingworth, deals with economic application of electricity to space heating by all principal systems, and examines several sources of loss of which account must be taken in making comparison between different systems.

HOW VALUABLE Is This Service TO YOU?

THE six-month trial period of publication of "Selected Items from Engineering Index Service" in ELECTRICAL ENGINEERING closes with this issue.

TO GUIDE the Publication Committee in determining whether to continue or discontinue this department the question will be discussed at the delegates conference to be held during the summer convention in Asheville, June 22-26, 1931.

INDIVIDUAL comments and suggestions are invited; they should be made promptly and addressed directly to the A. I. E. E. Editorial Department, 33 West 39th Street, New York, N. Y.

The Electrical Heating of Buildings, R. Grierson. *Instn. Elec. Engrs.—Advance Paper*, Mar. 2, 1931, 48 pp., 21 figs. Types of electric warming equipment; general details and considerations; ascertained monthly cost of continuous electric warming of individual rooms in Central London; graph showing estimated and actual weekly consumption for 20-kw. low-temperature ceiling-panel installation; graph connecting mean temperature-rise and weekly consumption for 20-kw. low-temperature ceiling-panel installation; data relating to thermal-storage installations; data relating to direct electric heating installations, etc.

Hoists

MOTORS. Application of Two-Speed Induction Motors to Monorail Electric Hoists, C. E. Schirmer. *Am. Soc. Mech. Engrs.—Advance Paper*, for mtg. Apr. 13-18, 1931, 2 pp. Use of two-speed squirrel cage induction motors upon monorail hoists has been neglected until recently, and since use of such motors bestows worth while operating characteristics to such hoists at low cost, their more frequent use for such service is assured; chart showing actual speeds for various loads S-1 1-ton 2-speed Robbins & Myers electric hoist.

Hydroelectric

AUTOMATIC POWER PLANTS. Fully Automatic Hydro Power Plant, P. J. Croft, J. R. Desloover and D. Hutchison. *Can. Engr.*, vol. 60, no. 10, Mar. 10, 1931, pp. 11-14, 6 figs. Operation of electrical equipment at Upper Notch Plant of Northern Ontario Power Co.; equipment consists of two 48-ft. head, 6,500-hp., 125-r. p. m. hydraulic turbines direct connected to two 6,500-kva., 11,000-volt, 25-cycle generators; fully automatic control and switching equipment designed for possible remote control from distant supervisory plant; metal-clad switchgear; four 4,500-kva., 11,000/110,000-volt, 25-cycle transformers.

13,000-hp. Fully Automatic Hydroelectric Plant, P. J. Croft, D. H. Hutchison and J. R. Desloover. *Elec. News*, vol. 40, no. 6, Mar. 15, 1931, pp. 39-42 and 48, 7 figs. Upper Notch plant of Northern Ontario Power Co., situated on Montreal River 12 mi. south of Cobalt in heart of Canada's greatest mining district, is one of Canada's largest fully automatic hydroelectric generating stations and represents latest practise in this type of control; it contains two 6,500-kva. 11,000-volt, 25-cycle generators, two 48-ft. head, 6,500-hp. 125-r. p. m. turbines, with fully automatic control.

POWER PLANT EFFICIENCY. Automatic Hydro Plant Economy Proved by Experience, J. M. Gaylord. *Elec. World*, vol. 97, no. 12, Mar. 21, 1931, pp. 532-535, 4 figs. Program of rehabilitation of smaller hydroelectric plants, which has resulted in 17 of these plants being made automatic or semi-automatic by Southern California Edison Co., Ltd., since 1919; 11 years' experience in operation of semi-automatic plants on system has demonstrated very definite savings in operating labor; under manual operation 17 plants required 77 operators while with automatic operation 33 operators are employed; reduced labor cost and housing expense amount to 57 per cent and turnover to 66 per cent; plants pay for themselves in 5½ years.

Hysteresis

Recherches sur la thermodynamique de l'Hystérésis (Studies on the Thermodynamics of Hysteresis), A. Guilbert. *Societé Francaise des Électriciens—Bul.*, vol. 1, no. 2, Feb. 1931, pp. 175-202, 11 figs. Experimental verification of theory expounded in Revue Générale d'Electricité of Jan. 5, 1929, indexed in Engineering Index 1929, p. 970.

Industrial Plants

PURCHASED VS. GENERATED POWER. Was darf die Kilowattstunde kosten? (Permissible Cost of Kilowatt Hour; Diesel Engine vs. Electric Motor), K. Dolzmann., *Elektrizitaetswirtschaft*, vol. 30, no. 6, Mar. 1931, pp. 149-157, 13 figs. General viewpoints for decision in problems of purchase of electric power or generation in own plant are discussed for small and average plants; factors and possibilities to be considered in valuation of Diesel engine and electric motors for this type of plant are analyzed; all necessary data for both types are given.

Insulating Oil

CARBON BLACK EFFECT. Effect of Carbon Black on Insulating Oils, W. B. Wiegand, C. R. Boggs and D. W. Kitchin. *Indus. and Eng. Chem.*, vol. 23, no. 3, Mar. 1931, pp. 273-276, 6 figs. Series of experiments designed to illustrate mechanism of action of carbon black is described; results indicate that action is one of removing moisture and/or electrolytes; brief summary of other methods for treating new and used insulating oils and of more important literature.

DIELECTRIC LOSSES. Dielektrische Verluste in Oelen (Dielectric Losses in Oils), A. Gemant. *Zeit. fuer. Technische Physik*, vol. 11, no. 12, Dec. 1930, pp. 544-545. Proof that losses in oil at low frequencies are due to different process (Wagner effect) from that causing them at high frequencies (Debye effect).

Lamps

Urges Large Lamps in Modern Illumination, M. M. Samuels. *Elec. World*, vol. 97, no. 13, Mar. 28, 1931, pp. 595-597, 1 fig. One peculiar feature has established itself in whole development of modern lighting equipment; it is so persistent and so objectionable that it seems necessary to discuss it in detail; getting away from candles and round bulbs, modern units appear principally in form of flat glass over very shallow fixtures or long glass panels or metal panels likewise on very shallow fixtures, all requiring long tubular lamps. Before Illum. Eng. Soc.

GLOW. Neue Gasentladungslichtquellen (Novel Gas Discharge Sources of Illumination), M. Pirani. *Lichttechnik (Supp. to Elektrotechnik u. Maschinenbau)*, vol. 8, no. 1, Mar. 15, 1931, pp. 1-3, 2 figs. New types in which many of disadvantages of previous types have been overcome; they are manufactured in two types, one with excitation in negative glow light used for television and similar purposes and high-capacity tubes with excitation in positive column; efficiency is 15 to 20 per cent.

Light and Lighting

Moderne Beleuchtungsarten und Leuchten, ihre Anwendung, Anlage und Wirtschaftlichkeit (Modern Methods of Lighting and Equipment, Their Application, Installation and Economy), G. Herkt. *Deutsche Bauzeitung*, vol. 65, no. 11-12, Feb. 4, 1931, pp. 29-36, 48 figs. Object and light intensity; room lighting and color; table showing light intensities for various rooms and locations; outside lighting; various samples of modern interior and exterior lighting; show window, indoor lighting, etc.

Foot-Candle Effectiveness a Measure for Illumination, M. Luckiesh. *Elec. World*, vol. 97, no. 12, Mar. 21, 1931, pp. 553-554. Reasonableness of demand for 10-ft. candles for visual work of this type may be tested; visibility of letters in telephone directory with letters of same size printed on fine book-paper with deep black ink are compared in table.

FILTERS. Filters for the Reproduction of Sunlight and Daylight and the Determination of Color Temperature, R. Davis and K. S. Gibson. *U. S. Bur. Standards—Miscellaneous Pub.*, no. 114, Jan. 21, 1931, 165 pp., 71 figs. Spectral energy distributions; component materials of filters; methods of computation; use of filters; spectrophotometric data; examination and trial of completed filters; preparation of Davis-Gibson filters. Bibliography.

VISUAL EFFICIENCY. Visual Performance Under Daylight, Incandescent, Mercury Vapor, and their Mixtures, K. Y. Tang. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 3, Mar. 1931, pp. 258-274, 6 figs. partly on supp. plates. Rapidity with which detail of test object could be perceived, using, at same levels, usual light sources, alone and in combination; illumination levels studied were 5- 10- and 20-ft. candles in test object; each kind of light was used separately at all three intensities, and combinations of two and three kinds in equal amounts were also used at all three levels.

Lightning

CONDUCTORS. Lynafledere (Lighting Erector), L. Ernst. *Elektroteknikeren*, vol. 27, no. 4, Feb. 22, 1931, pp. 67-79, 12 figs. Study of proper layout and wiring of conductors for all types of buildings; importance of factor controlling action of lightning conductor such as dimensions of building and materials, geological factors, etc.

Materials Handling

MANUFACTURING PLANTS. Material Handling in Mass Production at the General Electric Plant, H. C. Rundle. *Am. Soc. Mech. Engrs.—Advance Paper*, for mtg. Apr. 13-17, 1931, 5 pp. Conveyor system used throughout various buildings where refrigerators are made at General Electric Co., has eliminated congestion, retracing of material routes, delays in schedule, spoilage of materials, and maintenance and replacement of industrial trucks; conveyor serves as traveling stockroom, thus releasing floor space for use in manufacturing operations.

Measurements

ALTERNATING-CURRENT. A New Series of Alternating Current Instruments. *World Power*, vol. 15, no. 87, Mar. 1931, pp. 199-201, 4 figs. Alternating current measurements have long been at disadvantage as compared with direct-current measurement; perfection, during last few years, of dry copper-oxide rectifier has put a-c. testing on different basis; design and operation of rectifier operated instrument.

Metering

THREE-PHASE. The Metering of Three-Phase Supplies, O. Howarth. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 411, Mar. 1931, pp. 381-393 and (discussion) 393-403, 15 figs. Development of electricity supply during recent years has resulted in complexity in metering of three-phase supplies and has confronted meter engineer with task of achieving accuracy under difficult conditions; large bulk supplies are most complex and demand high standard of accuracy for commercial reasons; each additional complexity introduces additional source of error and paper deals with inaccuracies introduced by auxiliary apparatus and special equipment.

Motors

LOADS. Motors for High-Inertia Loads—II, R. E. Emerson. *Indus. Eng.*, vol. 89, no. 3, Mar. 1931, pp. 130-132, 2 figs. Consideration of energy stored in flywheel; use of high inertia in flywheels for handling peak loads while motor runs at full-speed.

MAINTENANCE AND REPAIR. Electric Motor Operation and Maintenance—II, G. H. Emerson. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 423-425. Methods of procedure in determining condition of machines; instruments used; overhauling and repair.

STARTING. Un nouveau démarreur automatique pour moteurs électriques (New Automatic Starter for Electric Motors). *Science et Industrie*, vol. 15, no. 205, Feb. 1931, pp. 85-87 and 92, 3 figs. New electrolytic starter of Rene Planchi Co. in Villefrance sur Saone is described; advantages and field of application are outlined.

TESTING. Tests of Rotating Electrical Apparatus for Electrical Characteristics, A. C. Roe. *Power Plant Eng.*, vol. 35, no. 6, Mar. 15, 1931, pp. 372-373. Practical discussion of proper methods to be employed in electric motor tests.

RAILROAD. Field Shunting and Modern Motor Design, L. B. Hewitt. *Elec. Ry. Bus and Tram Jl.*, vol. 64, no. 1596, Mar. 13, 1931, pp. 141-143, 3 figs. Metropolitan Electric Tramways carried out experiments several years ago, on their 40-hp. non-interpole motors, using field shunting with object of increasing top speed and improving acceleration; this was arranged by means of contactor which was energized on last notch of controller, but under control of specially designed relay which automatically prevented shunting coming into operations if conditions were such that current would rise above predetermined amount.

Comparaison du couplage série-parallèle et du couplage série permanent des moteurs compound dans les systemes à récupération (Comparison of Series-Parallel and of Permanent Series Coupling of Compound Motors in Regenerative Systems), F. Guery. *Revue Générale de l'Electricité*, vol. 29, no. 10, Mar. 7, 1931, pp. 381-385, 3 figs. Comparison of systems of Bacqueyrisse and Lièvre; study has bearing upon essential characteristics of motors and regarded from standpoint of dimensions, all other conditions remaining same; author points to importance of losses in series parallel system.

Networks

Fundamentals of the Medium Voltage Network, D. K. Blake. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 210-217, 17 figs. Modern a-c. low-voltage 120/208-volt network has brought out substantial economies, simplification, flexibility, and standardization involved in network principle; it is not generally recognized that network principle is applicable at medium voltage (4,000 volts) to residential and industrial areas having very low densities.

MAINTENANCE AND REPAIR. De l'organisation du controle permanent de la construction et de l'exploitation d'un réseau rural de distribution d'energie électrique (System for Permanent Supervision, Construction and Exploitation of Rural Distribution Network), L. Melot. *Revue Générale de l'Electricité*, vol. 29, no. 11, Mar. 14, 1931, pp. 429-437, 4 figs. Simple schematic and accurate number identification and index scheme for repairs, extensions, etc. for network system in continuous process of development; method has been successfully applied by author on networks of Loir-et-Cher district.

Ohmmeters

Ein neues Megohmmeter (New Megger), W. Jaekel. *V. D. I. Zeit.*, vol. 75, no. 11, Mar. 14, 1931, p. 316, 2 figs. New type of Siemens and Halske for measurement of insulating resistances of machinery equipment and cables up to many thousands of megohms; easy handling is featured.

Permeameters

TESTING. A Method for the Standardization of Permeameters at High Magnetizing Forces, R. L. Sanford. *U. S. Bur. Standards—Jl. Research*, vol. 6, no. 3, Mar. 1931, pp. 355-362, 6 figs. Apparatus suitable for testing of standard magnetic test bars to be used for standardization of magnetic permeameters with high magnetizing forces; criterion is given for determining when accurate values have been obtained; attention is called to necessity that standards shall be magnetically uniform.

Photoelectric Cells

Photoelectric Tube Increasingly Applied in Industry, J. W. Marshall. *Iron Age*, vol. 127, no. 13, Mar. 26, 1931, pp. 1012-1013, and 1067-1068, 3 figs. Operation principles and industrial application including application to problem of packaging machine design.

Construction, Operation and Characteristics of Photoelectric Tubes, L. R. Koller. *West. Soc. Engrs.—Jl.*, vol. 36, no. 1, Feb. 1931, pp. 15-25, 15 figs. Guide to intelligent selection to accomplish desired results.

Power Factor

Power Factor Correction in Industry, J. Murray. *Blast Furnace and Steel Plant*, vol. 19, no. 4, Apr. 1931, pp. 560-563, 8 figs. Simple method and equipment for power-factor correction in industrial plants.

Radio

AERIAL COMMUNICATION. European Aviation Radio, G. C. Gross. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 341-350 and (discussion) 351-352, 15 figs. Observations made on inspection trip over major European airways; aviation radio in Europe differs from aviation radio in United States in prevalent use of intermediate frequencies exclusively; it may be divided into communication from ground to plane and plane to ground; point-to-point communications in connection with traffic dispatching of aircraft; meteorological communication relating to safe flying conditions.

BROADCASTING. Ten Years of Broadcasting, C. W. Horn. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 356-376, 15 figs. Salient points in development of broadcasting during last decade are reviewed; it is shown that further improvement may be expected with more extensive introduction of higher powered transmitters.

DETECTORS. Grid Circuit Power Rectification, J. R. Nelson. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 489-500, 7 figs. Grid circuit power rectification is investigated by studying ideal rectifier and applying results obtained to case of tube rectifier; characteristic curves are used in this study to obtain optimum conditions for rectification and order of output voltage obtainable; conditions for minimum loading of circuit preceding detector are discussed.

ELECTROLYTIC CONDENSERS. Electrolytic Condensers for Radio Use, F. W. Godsey, Jr. *Electronics*, vol. 2, no. 4, Apr. 1931, pp. 596-597, 4 figs. Principles, equipment and its construction are described; electric and performance characteristics are given.

GENERATOR FREQUENCY. The Design of Radio-Frequency Signal Generators, J. R. Bird. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 438-451, 5 figs. Certain factors involved in designing signal generators free from stray voltage errors are considered; importance of accounting for all circuit details, particularly of wiring elements, is stressed; impedances of certain connections, particularly of output connections from generator to measured receiver, are shown to be important; shielding is considered in some detail.

MEASUREMENTS. Measurement of Resistance and Impedances at High Frequencies, J. W. Labus. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 452-460, 4 figs. It is shown that absolute value of unknown impedance, when put across end of transmission line, is simple function of ratio of currents, measured at beginning and end of transmission line; method has been tested out at wavelength of 21.8 meters, measuring resistance of number of grid leads and of decade box; a-c. resistance was considerably higher than labeled d-c. value; at same time shunted capacity across resistors has been measured and value have been obtained, which agree with expectations.

OSCILLATORS, PIEZOELECTRIC. Measurements of Temperature Coefficient and Pressure Coefficient of Quartz Crystal Oscillators, S. L. Brown and S. Harris. *Rev. Sci. Instruments*, vol. 2, no. 3, Mar. 1931, pp. 180-188, 2 figs. Method of measurement is used whereby variation in frequency of high frequency oscillator can be measured easily to fraction of part in million; audible different tone produced by harmonic of constant, high frequency oscillator and harmonic of second oscillator is compared to tone of variable, calibrated audio frequency oscillator.

OSCILLATION. Oscillation in Tuned Radio-Frequency Amplifiers, B. J. Thompson. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 421-437, 4 figs. Wide use of screen-grid tubes renders understanding of conditions for stability of tuned radio-frequency amplifiers important; in this paper relation between feed-back capacity and other circuit and tube parameters at threshold of instability is computed for one, two, three and four stages.

RESISTANCE. Resonant Impedance and Effective Series Resistance of High-Frequency Parallel Resonant Circuits, H. Iinuma. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 467-478, 11 figs. Example of application of method published in same journal, March 1930, p. 537, "A method of measuring radio-frequency resistance of oscillatory circuit."

SHORT WAVE. Radio Communication on Very Short Waves. *Engineering*, vol. 131, no. 3404, Apr. 10, 1931, pp. 482-483, 7 figs. Experiments are being made on wavelength of 18 cm. by International Telephone and Telegraph Laboratories, Inc., of Hendon, and Laboratories of "Le Matériel Téléphonique," of Paris, between St. Margaret's Bay, near Dover, and Cap Blanc, in France; apparatus used for this purpose, mainly developed by French engineers, consists of terminal equipment of normal design, which is connected to transmitter and receiver.

Railroads

ELECTRICAL ENGINEERING. Report of the Committee on Electricity. *Ry. Age (Daily Edition)*, vol. 90, no. 10B, Mar. 11, 1931, pp. 528-D44-45 and (discussion) 528-D45-46. Synopsis of matter presented before electrical section, Am. Ry. Assn., in October, 1930. Before Am. Ry. Eng. Assn.

ELECTRIFICATION. Thirty-Five Years' Experience with Heavy Electric Traction, S. Withington. *Ry. Age*, vol. 90, no. 12, Mar. 21, 1931, pp. 577-579. Satisfactory equipment has been found; conditions justifying electrification have been determined; need of unified system; era of expansion; early New Haven experience; important developments based on experience. Before New York Railroad Club.

INTERLOCKING SIGNALS. New Control System Used at Electric Interlocking on the Burlington, W. F. Zane. *Ry. Signaling*, vol. 24, no. 3, Mar. 1931, pp. 81-84, 6 figs. Independent control and indication circuits make for simplicity, reliability and freedom from grounds; signal layout plan; tower and power equipment at Downers Grove, Ill.; interlocking machine; outside construction; control and indication circuits; locking and signal circuits.

Remotely-Controlled Interlocking Solves Problem on C. and N. W., S. E. Noble. *Ry. Signaling*, vol. 24, no. 3, Mar. 1931, pp. 85-86, 4 figs. Extensive plant at West Nelson, Ill. controlled from desk levers in tower at another interlocking; track and signal plan of remotely-controlled plant; change in layout and circuit design; lever indication lights; outside construction.

OPERATION STATISTICS. Electric Railways Carry On in a Year Beset with Difficulties. *Elec. Ry. Jl.*, vol. 75, no. 4, Apr. 1931, pp. 197-200. Operating economies obtained in 1930 offset in large measure decreased revenues that were general; reports from 75 companies operating transportation lines in United States and other countries analyzed to give significant statistics; table of condensed financial reports of electrical railway properties 1930-1929.

Rectifiers

HIGH CAPACITY. High Power Rectifiers, J. W. Rissik and H. Rissik. *Engineer*, vol. 151, no. 3923, Mar. 20, 1931, p. 322. Editorial review of paper before Institution of Electrical Engineers, in which increasing field of application of rectifier is attributed to its economy on fluctuating loads, reliability under most severe operating conditions, rapidity with which it can be set to work, and fact that it is unaffected by disturbances on a-c. side; although discussion indicated that certain manufacturers are inclined to favor 600-volt rotaries, experiences on Continent and in America clearly show that engineers frequently specify rectifiers for 600 volts and similar pressures.

MERCURY-ARC. Mercury-Arc Power Rectifier Auxiliaries and Accessories, E. S. Waterman. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 228-234, 16 figs. Exhaust system; vacuum-measuring and regulating devices; ignition and excitation equipment; cooling system; thermal control devices; degassing equipment; resonant shunts and series reactor.

Refrigeration

The Young Engineer in the Refrigerating Industries, A. R. Stevenson, Jr. *Refrig. Eng.*, vol. 21, no. 4, Apr. 1931, pp. 256-258. Survey of possibilities for young engineer in refrigerating industries; classification of engineers by General Electric Co. together with qualifications and possibilities in following four classes: development, design, application and sales engineering.

Regulation

MACHINERY. Ueber die Reglung von Spitzenlast und Grundlastmaschinen (Regulation of Peakload and Base Load Machinery), W. Kieser. *Elektrizitaetswirtschaft*, vol. 30, no. 6, Mar. 1931, pp. 164-170, 13 figs. It is shown what unavoidable frequency fluctuations result in three-phase network from changes in load and how these fluctuations may be kept within narrow limits.

Remote Control

SHIP STEERING GEARS. Der sympathische Fernantried fuer Regel- und Umkehrorgane von Rudermaschinen (Electric Control of Ship Steering Gear), H. Kohrs. *Schiffbau*, vol. 32, no. 3, Feb. 1, 1931, pp. 60-64, 9 figs.; see also brief translated abstract in *Mar. Engr. and Motorship Bldr.*, vol. 54, no. 642, Mar. 1931, p. 116. Disadvantages of normal steering rod and chain control of rudder quadrant; electric installation by A. E. G., known as sympathetic distance control, is so arranged that rudder accurately and immediately follows each unit degree change in rotation of steering wheel; steering engine valve is controlled by geared motor supplied with current from Leonard motor-generator.

Resistors

DESIGN. Stromregelungen bei Laboratoriumsmessungen (Current Regulation in Laboratory Measurements), G. Hauffe. *Elektrotechnische Zeit.*, vol. 52, no. 11, Mar. 12, 1931, pp. 340-341, 4 figs. For exact adjustment of current readings, parallel dimensions of resistors is often required; range of regulation and dimensions of such equipment are discussed and curves for quick design are developed.

Rheostats

Theory of a Combined Series and Potentiometer Rheostat, J. R. Nielsen. *Rev. Sci. Instruments*, vol. 2, no. 3, Mar. 1931, pp. 184-186, 1 fig. Theoretical mathematical analysis pertaining to rheostat designed by Dodge and which permits rapid change from series to potentiometer connection, or vice versa, by simple closing or opening switch.

Sound Measurement

Mesure des intensités sonores par la méthode des scintillations (Measurement of Sound Intensities by Scintillation Method), F. Canac. *Physique et le Radium—Jl.*, vol. 2, no. 2, Feb. 1931, pp. 42-60, 10 figs. Theoretical analysis, measurements and results of experiments.

Spectrum Analysis

Energy Measurements in the Visible and Ultraviolet, F. Bendord and R. F. Howe. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 3, Mar. 1931, pp. 292-301 and (discussion) 301-305, 6 figs. Three common ways of making energy analysis in visible and ultraviolet are photographic method, filter method and monochromator method; these three methods are not fully interchangeable and nature of source of energy often dictates which shall be used; inherent limitations of all three are discussed with reference to measurements of sunlight and some of common sources of light and ultraviolet radiation.

Substations

INDUSTRIAL. Industrial Plant Substations, O. H. Henschel. *South. Power Jl.*, vol. 49, no. 3, Mar. 1931, pp. 67-72 and 74, 9 figs. Notes on indoor and outdoor types of industrial plant substations; general layout and equipment design; typical installations; multiple transformer stations; combination stations; secondary substations.

LIGHTING. Outdoor Substation Lighting, H. E. Hutter. *Elec. Rev.*, vol. 108, no. 2781, Mar. 13, 1931, pp. 460-461, 5 figs. Principles of underlying provision of adequate illumination to meet requirements both of normal operation and emergency repair work; samples of lighting units to be used, design and construction and details are given.

Synchronizers

AUTOMATIC. Automatic Synchronizing Equipment. *Power Engr.*, vol. 26, no. 300, Mar. 1931, pp. 105-109, 12 figs. Principles of and apparatus for synchronizing a-c. generators automatically; Brown-Boveri apparatus for automatic synchronizing; Reyrolle system; performance curves and diagrams.

Transformers

AUTO. Auto-Transformers for Starting Induction Motors, A. Holt. *Power*, vol. 73, no. 13, Mar. 31, 1931, pp. 508-510, 3 figs. Although induction motors designed for starting on full voltage have come into general use, there are vast numbers in service that are started on reduced voltage; voltage supplied by auto-transformers; practical discussion of selection and care of electric equipment.

GROUNDING. Grounding Transformers, H. Fahnoe and E. G. Reed. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 226-230, 10 figs. On three-phase power system grounding transformer is frequently used not only to provide neutral ground connection, but also to limit to predetermined value current flowing during line-to-ground fault; notes on star-delta connected grounding transformers; interconnected-star grounding transformer; thermal protection of grounding transformers; equivalent kv. rating of grounding transformers; numerical examples.

INSTRUMENT. Current Transformers, G. W. Stubbings. *Elec. Rev.*, vol. 108, no. 2871, Mar. 13, 1931, pp. 462-463, 1 fig. Critical study of various methods of determining errors; vector relationships; absolute methods of testing; comparison methods of testing; elimination of detector errors; novel comparison methods.

Waves

TRANSIENT. Die Umbilding der Wellenform durch Kapazitaeten und Induktivitaeten bei durch Funken ausgeloesten Wanderwellen (Reshaping of Wave Form by Capacity and Inductance of Spark Generator Traveling Waves), W. Schilling. *Archiv fuer Elektrotechnik*, vol. 25, no. 2, Feb. 21, 1931, pp. 97-122, 21 figs. Voltage characteristic of waves in simple circuit; approximate equations for large breaking capacities; influence of capacity and inductivity in wave form and voltage.

ULTRA-SHORT. Sur la réflexion des ondes électromagnétiques (Reflection of Electromagnetic Waves), C. Gutton and G. Beauvais. *Académie des Sciences—Comptes Rendus*, vol. 191, no. 26, Dec. 29, 1930, pp. 1418-1420; see also translated abstract in *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 143-144. Experiments with reflected ultra-short waves from 6 to 10 m. and results obtained.

Welding

HYDRAULIC TURBINES. Hydraulic Turbine Repaired by Electric Welding, C. R. Reid. *Power*, vol. 73, no. 12, Mar. 24, 1931, pp. 478-479, 3 figs. Badly damaged Francis-type runner of 20,000-hp. unit repaired at cost of only $2,274.

PIPE LINES. 1930 Piping Jobs Simplified by Welding. W. R. Wood. *Heat. and Piping Contractors Nat. Assn.—Off. Bul.*, vol. 38, no. 4, Apr. 1931, pp. 37-39, 9 figs. Advantages of welding as exemplified by Empire State and Cornell Medical Center installations.

SHEET STEEL. Sheet Metal Welding Formulae. *Sheet Metal Industries*, vol. 4, no. 11, Mar. 1931, pp. 984, 986, and 989, 3 figs. Up to present, literature of welding processes reveals almost complete absence of formulas; first attempt to obtain such laws carried out by D. Seferian; results of tests are shown in table and are also represented graphically.

SHIPBUILDING. Experiences with an Electrically-Welded Ship. *Engineering*, vol. 131, no. 3403, Apr. 3, 1931, pp. 460-461, 3 figs. Fullagar, now known as Shean, was launched in 1920; vessel has several times been aground and on each occasion, later examination showed keel and bottom plating to have stood severe conditions without ill effect; after more than 11 years of service it has been impossible to trace any undue corrosion in welded structure; experiences form remarkable demonstration of possibilities of electric welding in ship construction and valuable tribute to methods and materials of Quasi-Arc Co.

TRACKS. Welding Manganese Track Work, H. H. George. *Traction Shop and Roadway*, vol. 4, no. 3, Mar. 1931, pp. 77-80, 16 figs.; see also *Elec. Traction*, vol. 27, no. 3, Mar. 1931, pp. 125-127, 16 figs. Knowledge of, and adherence to fundamental requirements, found through experience, results in long life for track work reconstructed by welding; Cleveland's welding rules; frequent repairs to frogs handled quickly by welding; switch repairs that save money and prevent derailments.

Industrial Notes

Lamp Companies Merge.—Plans for a merger have been approved by the directors of the Hygrade Lamp Company of Salem, Mass., and the Sylvania Products Company and the Nilco Lamp Works, Inc., both of Emporium, Penn. Combined sales of these companies amounted to approximately $9,000,000 for the year 1930. The Emporium and Salem units each manufacture incandescent lamp bulbs and radio tubes. The electric lamp bulbs are manufactured and sold under a license agreement with the General Electric Company.

A New Rectifier.—A new line of heavy duty rectifiers has been announced by the B-L Electric Manufacturing Company, St. Louis, supplementing the small rectifiers which the company has produced for some years. These rectifiers are constructed entirely of metal plates without any moving parts and are of rugged construction. They are used to obtain low voltage direct current from the ordinary alternating-current lines and for this purpose require the use of small step-down transformers. Many applications exist for the use of such rectifiers in the fields of radio, sound-film equipment, signaling, alarms, industrial control, etc. B-L Electric Mfg. Company, 19th & Washington Avenue, St. Louis.

New G-E Plant Near Completion.—The new million dollar Cleveland wire works plant of the General Electric Company, which is being erected at South Euclid, on the outskirts of Cleveland, is rapidly nearing completion, according to E. J. Edwards, engineer in charge of plant construction for the incandescent lamp department. The new plant, which is to be devoted to the manufacture of filament wire, represents the largest arc-welding job ever attempted in the Cleveland territory. More than a thousand tons of structural steel are going into its construction. The building covers an area 493 feet in length by 320 feet in width. It will provide 185,000 square feet of floor space. Tentative production schedules call for a plant output of more than 300,000 miles of filament wire during the year 1932. The structure is scheduled for completion August 15 by the Austin Company, of Cleveland, who built the original Nela Park in 1912.

A New Power Filter Unit.—The Square D Company, Detroit, has announced the introduction of a power filter unit for supplying noiseless, non-pulsating, direct-current power from ordinary alternating-current circuits and applicable to telephone circuits, intercommunicating systems, public address systems, talking picture equipment and other sound producing apparatus. No auxiliary equipment is necessary. The new device is noiseless and has no moving parts. Square D Company, Detroit.

Installing Underground Cable.—By means of a special plow built by the General Electric Company, the plow being available for rental purposes, parkway or underground cable can be installed beneath sod and in locations where a minimum disturbance to the ground is desired. A reel of parkway cable is located at one end of the circuit run, and is mounted on supports so that it may unreel easily. The plow is connected to a tractor, and one end of the parkway cable is connected to the plow blade. It may be used to best advantage when installing parkway cable within the curb line of a street, around tree roots, poles, etc. The depth limit of the plow is 15 inches.

Trade Literature

Airport Lighting.—Catalog 218-FA, 30 pp. Describes a complete line of electrical equipment necessary for airport lighting. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Vitrohm Resistors.—Bulletin 507, 8 pp. Describes vitrohm resistors and rheostats for radio. Ward Leonard Electric Company, Mount Vernon, N. Y.

Carbon Brushes.—Catalog 12, 42 pp. Describes a complete line of standard and special brushes for motors, generators and synchronous converters. Boxill-Bruel Carbon Co., Columbia Park, Ohio.

Small Generator Units.—Bulletin 1908, 12 pp. Describes belt driven generators, turbine generator units, portable gas engine-driven power units and electric service plants up to 15 kw. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Line Hardware.—Bulletin 5, 4 pp. Describes guying specialties, including guy hooks, eye nuts, curved ribbed washers, double guy blocks, Shull boltless guy clamps, and "pick-up head" anchor rods. Malleable Iron Fittings Company, Branford, Conn.

Th Stenode.—Bulletin 1, 24 pp. Describes the "Stenode," for which the claim is made that it is by far the most selective radio receiver. Drawings of various circuits are included. The Stenode Corporation of America, Hempstead Gardens, L. I., N. Y.

Instruments.—Catalog F Part 2, 48 pp. Supplement to Part 1 of Catalog F. Describes all new General Radio instruments'for electrical measurements at communication frequencies, and announces many important specification changes in the others. General Radio Company, Cambridge, A, Mass.

Circuit Breakers.—Bulletin 37, 16 pp. Describes Pacific Electric multi-break oil circuit breakers. These 69-kv. breakers incorporate many new features and improvements over former types. Pacific Electric Manufacturing Corp., 5815 Third Street, San Francisco.

Remote Control Cars.—Bulletin 1239, 12 pp. Describes automatic and remote control quarry cars which are controlled by one operator from a distant point. The idea of remote control is not entirely new, but the scheme described in the bulletin depends upon the use of alternating current, which has not heretofore been employed in such operation. The Atlas Car & Mfg. Co., Cleveland.

Manual of "Megger" Practice.—A pocket manual, 96 pp., treating in a comprehensive manner on the subject of electrical insulation and uses of insulation testing instruments. It includes valuable data on the characteristics of insulation and suggests how and where to look for insulation defects in electrical equipment. Sixty-seven illustrations are included. James G. Biddle Company, 1211 Arch Street, Philadelphia.

Lightning Arresters.—Bulletin 313, 64 pp. Describes a complete line of lightning arresters, including Keystone crystal valve lightning arresters for high and low voltage a-c. service and for low voltage d-c. service; Garton-Daniels lightning arresters for low-voltage a-c. and d-c. service and for standard and high voltage d-c. railway service; Keystone and Protex radio lightning arresters; and ground fittings. Electric Service Supplies Co., 17th & Cambria Streets, Philadelphia.

Motors.—Bulletin 165. Describes seven distinct types of squirrel cage motors, comparing them as to their starting torques, starting currents and cost. Speed-torque curves and tables make a thorough comparison of the seven types to enable a proper selection for different applications. The bulletin also describes construction details, and has a section on "mechanical variations" in which roller bearings, totally-enclosed, fan-cooled, vertical and three-bearing motors are discussed. There is also a section on multi-speed motors and control equipment. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 7

The JOURNAL of the A.I.E.E. for July 1 31

WILLIAM S. LEE, *President*
F. L. HUTCHINSON, *National Secretary*

Publication Committee

W. S. GORSUCH, *Chairman*
H. P. CHARLESWORTH E. B. MEYER
F. L. HUTCHINSON A. E. KNOWLTON

Publication Staff

GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in ELECTRICAL ENGINEERING are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited in all controversial matters.

REPUBLICATION from ELECTRICAL ENGINEERING of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index.

Printed in the United States of America.
Number of copies this issue—

24,250

This Month—

Front Cover

Lightning—as seen from the mountains overlooking Los Angeles and Pasadena, California

—General Electric Co. Photo

Relay Protection for a "Close-Linked" System 471
By T. G. LeCLAIR

Overseas Radio Telephone Service 476
By F. A. COWAN

Theoretical Studies, Laboratory and Field Tests, Operating Experiences, Lead to Effective System Protection Against Lightning Disturbances 478

Theories of Lightning Discharge and Traveling Waves . 481

Field Tests with Artificial Lightning 487

Field Tests with Natural Lightning 490

Protection Against Lightning Surges 498

Lightning vs. System Operation 501

—— Turn to Next Page

Single Patent Appeal Court is Proposed 502
By EDWIN J. PRINDLE

Twin Motors for Heavy Rolling Mills 506
By R. H. WRIGHT & H. E. STOKES

A Vacuum-Tube Device for Current-Balance Telemeters . . 510
By B. E. LENEHAN & PAUL MacGAHAN

Coordination—The Essence of Modem Engineering 512
By W S. LEE, President, A. I. E. E.

Short Items—

Magnetic "Iron" Perfected by Research 475
Clinical Sunlight—Natural and Artificial 511

News of Institute and Related Activities 514
Local Institute Meetings 526
Employment Notes 531
Membership 534
Engineering Literature 535
Industrial Notes 540
Officers and Committees (For complete list see ELECTRICAL ENGINEERING January 1931 pp. 81-84.)

W. S. LEE (F'13) sagacious president of the Institute, in his summer convention address interprets the spirit of modern engineering in one word—*coordination*—and indicates therein a fruitful field of endeavor for the young engineer. (*See page 512.*)

STEEL MILL engineers especially may be interested in the development of twin-motor drive for heavy rolling mills. (*See page 506.*)

SUMMER CONVENTION news will be especially interesting to those unable to attend and participate in its varied technical and recreational program. (*See page 517.*)

OVERSEAS TELEPHONE service by radio first was introduced more than four years ago and now is accepted as quite the ordinary thing. Recent developments are described by F. A. Cowan (M'29). (*See page 476.*)

THE LIGHTNING SEASON being at hand, it is pertinent that serious attention be given to the effects of this phenomenon upon electric power transmission. Much has been accomplished by the Institute's lightning subcommittee since its appointment in 1926; the work has been greatly expedited within the past two years by the use of several new instruments, and by the concentration of effort upon a few systems. Important results of recent investigations, contained in twelve Institute papers, have been abstracted and correlated in six articles. (*See pages 478 to 502.*)

PACIFIC COAST convention with its excellent technical program embracing subjects from cathode drops to industrial applications, and its delightful admixture of recreational and entertainment features, offers first-class vacation possibilities. Why not take advantage of the special convention rates available at Tahoe Tavern for the entire convention week? (*See page 514.*)

ANNUAL MEETING of the Institute comprised the opening session of the summer convention; results of the recent election of officers, and the annual report of the board of directors, were among the important matters receiving attention. (*See page 522.*)

DR. W. J. FOSTER (F'16) recently awarded the Lamme Medal, was presented the trophy with appropriate ceremony during the summer convention. (*See page 519.*)

"FOR THE PURPOSE of studying the present and any proposed future activities of the Institute," the new Institute policy committee was appointed at the May 19 meeting of the board of directors. (*See page 523.*)

H. B. SMITH (F'13) past-president of the Institute, has resigned his post at Worcester Polytechnic Institute, and plans to resume professional practise. (*See page 524.*)

Relay Protection for A "Close-Linked" System

Relay-protection design involves a detailed study not only of the required standards of service but also of the general design and layout of the power system to be protected. The "close-linked" type of system of Chicago and the special relaying system which it demanded, are discussed.

By
T. G. LeCLAIR
Member, A. I. E. E.

Commonwealth Edison Co., Chicago, Ill.

SERVICE RELIABILITY required of electric power systems today is accomplished fundamentally by two general means. One might be termed "preventive engineering" and the other "protective engineering." The former presupposses a system and its related equipment designed and built to a degree of perfection that makes failure impossible while the latter aims to minimize and localize such troubles as may occur.

Obviously, *complete* prevention of failure is impossible of practical attainment; hence protection against line and apparatus failure becomes a necessity. Theoretically a fault is not considered serious provided the capacity and extent of equipment involved is small and that the protective equipment will operate to isolate the trouble quickly. From a power-system standpoint, therefore, protective devices are installed to protect the system as a whole, rather than individual lines or equipment, against the disturbing effects of faults.

General System Design

Of first importance in the matter of power-system protection is the question of the general system design; and so far as the larger cities of the United States are concerned, this may be classified into three principal types as follow:

1. "Loose-linked" system of Detroit.

Each group of distribution circuits is provided with a substation and for each group of substations there is a generating station of sufficient normal capacity to care for the group of substations operating from its buses. The loose-linking characteristic is found in interconnection of areas which are served by different generating stations with tie cables so designed as to have relatively low capacity compared to the total load emanating from a generating station, but of sufficient capacity to serve normal and emergency power interchange between different load districts. Thus, the different load areas are all linked together for normal service, but each is subject to quick and complete isolation from its neighbors, minimizing the possibility of any system-wide disturbance which might result from a serious fault in any load district. (See A. I. E. E. Trans., Vol. 48, Oct. 1929, pp. 1080-2.)

2. "Synchronized-at-the-load" system of New York.

All supply cables are short; generating stations are close to the load and all are of closely similar efficiency. Transmission and tie-lines are so arranged that any station may feed to any or all load centers. Thus the loss of any one source will not interrupt service at the load; power is widely available under emergency conditions and yet relatively low short-circuit currents arise, a factor of prime importance. (See A. I. E. E. Trans., Vol. 48, Oct. 1929, pp. 1080-2.)

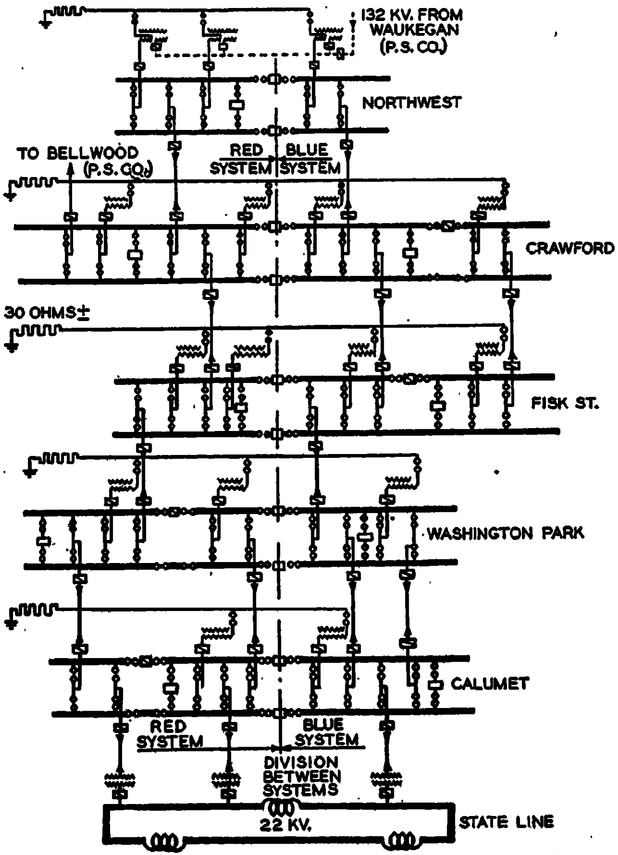


Fig. 1. Schematic diagram of Chicago "close-linked" transmission system. Note especially that system is normally divided into two distinct parts ("red" and "blue"), also that generating stations are connected by 66-kv. low-reactance tie cables

---

From talk presented informally at a joint meeting of the Chicago Section of the A. I. E. E., and the Western Society of Engineers, held in Chicago, Oct. 28, 1930. * Not published in pamphlet form.

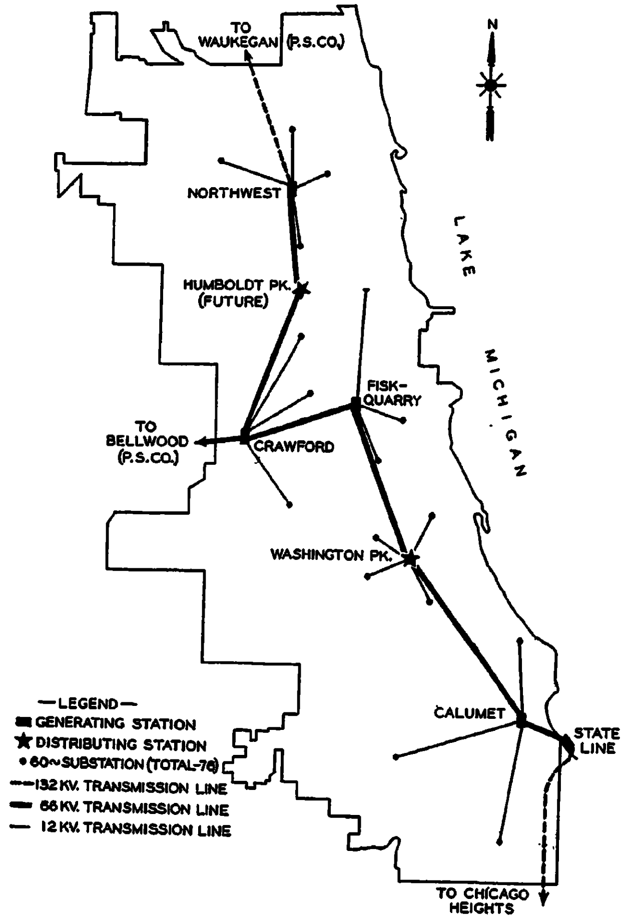


Fig. 2. Semi-geographic layout of Chicago 60-cycle system showing 66-kv. inter-station "bus"

3. Bus or "close-linked" system of Chicago.

This system is illustrated in Figs. 1 and 2 where various independent loads may be noted, each fed from separate sources. All sources are tied together through reactors, permitting a direct energy interchange. Such a scheme has certain limitations, the most serious being that short-circuit currents are large, thus requiring special means of accomplishing satisfactory circuit interruption.

For a power system such as the one in Chicago where several generating stations have been built more or less as units, the close-linked system is considered ideal. Of the generating stations indicated in Figs. 1 and 2, Fisk and Quarry stations are "old-timers," the newest units having been installed more than fifteen years ago. At Crawford station the oldest unit was installed some six years ago, while the oldest at State Line is less than two years old. Because operating efficiencies among these stations vary greatly, it is necessary to provide for a transfer of load between different sources in order to realize the best over-all operating economy.

This load transfer is accomplished through a 66-kv. "inter-station" bus which stretches the entire length of the city as may be seen in Fig. 2. All six steam-electric generating stations representing the aggregate installed capacity of 1,298,000 kw. are interconnected by means of this 66-kv. transmission bus. Electrically these station interconnections are extremely short, their reactance being so low that with maximum load the total voltage variation from one end of the city to the other does not exceed three or four per cent.

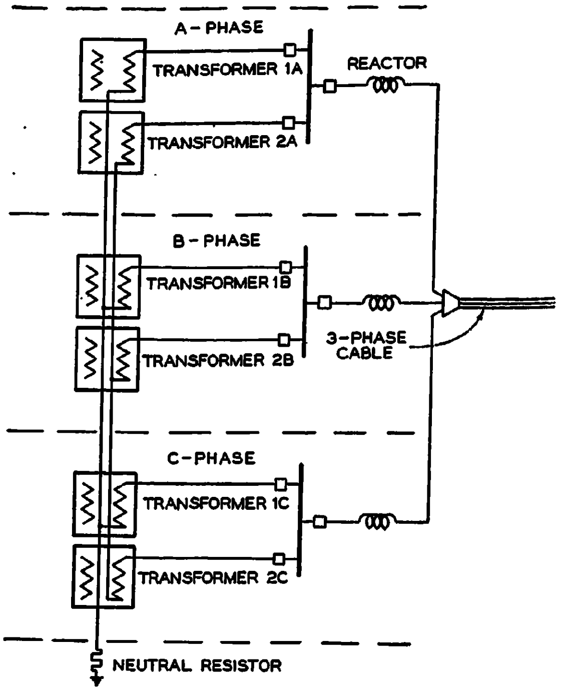


Fig. 3. Illustrating isolated-phase grouping of two transformer banks

With this system it is possible to tap off at any given station the load needed for that particular local territory the transformer capacity of the station in question being governed of course by the load to be served. However, there are certain difficulties involved because with this close-linked system any one fault member will involve the entire system. For this reason the system has been split throughout into two parts. The 66 kv. buses of the two parts are capable of interconnection in the various stations but only in rare cases are they actually operated tied together. Thus, there are practically two duplicate systems; and trouble on one of them will not interfere with the other. For purposes of clarity some of the illustrations refer to these two parts as "red" and "blue" systems.

ISOLATED-PHASE CONSTRUCTION

Short-circuit current which would arise if the two systems were operated tied together would be practically impossible to handle with the existing circuit-interrupting equipment and conventional group-phase construction. Even with the systems separated, the problem of handling the interruption of fault current is a serious one. An expedient which has done more than any other single thing to make practicable the operation of such a system is the isolated-phase construction. With this type of construction it is possible to throw the entire station capacity upon one bus, where emergencies require, yet the short-circuit current is low enough so that an ordinary circuit breaker can interrupt it satisfactorily.

A diagrammatic presentation of this isolated-phase arrangement is given in Fig. 3 where two transformer banks are shown so connected that both the phase unit of the bank itself and the phase leads from the bank are widely separated physically from those of adjacent phases. The leads are not brought close together until they have passed through suitable reactance capable of limiting the short-circuit current to an easily interruptable value.

Most important among the features of the isolated-phase system is the relatively-high resistance or reactance employed in the neutral connection. Normally, in a star-connected system all loads are carefully balanced between phases and practically no current flows through the neutral; on the other hand in the isolated-phase system, practically all fault current will flow through the neutral since phase-to-phase faults are almost impossible on account of the great physical separation between exposed parts. This greatly simplifies the protection problem without interfering in any way with the system regulation.

With the isolated-phase construction of a 66-kv. outdoor terminal not only are the phase leads separated by a distance of 30 ft. or more, but by a metal screen of generous proportions as well. (See Fig. 4.) In indoor generating station construction whether for 12 kv. or 66 kv. each phase is housed in a separate room or on a separate floor. This type of construction is used also for the newer and larger substations; in the older and smaller substations the arrangement of lines and buses is depended upon to prevent complete shut-downs. No two lines to a substation group originate on the same line bus but are divided among the different sections of the generating station main bus.

FAULT BUS FOR PROTECTING SWITCHING EQUIPMENT

As mentioned in the beginning of this article, protective equipment must be installed to guard against the disturbing effect of those failures which system design cannot prevent. To be ideal, of course, protective devices must disconnect faulty equipment only, and in addition operate instantaneously; this ideal is achieved or approached wherever economically justifiable.

Practically instantaneous clearing of faults can be secured by employing the fault bus, a device for system protection which is of maximum benefit with isolated-phase construction. It consists essentially of a separate bus isolated from ground but connected through a current transformer to the main ground bus. Each unit group of switching equipment has its own fault bus through which the oil switch tanks, insulator bases, and other equipment cases are grounded and to which flash plates are connected. These flash plates are so arranged that no flashover can occur without the resultant current flowing through the fault bus and its current transformer. A relay in this current transformer secondary circuit can be set for instantaneous operation and the unit group wherein the fault occurs will then be quickly isolated. A schematic diagram of the fault-bus connections in a generating station switchhouse may be seen in Fig. 5. Here two main buses with outgoing lines are connected to so-called line buses; all can be fed from either one of the main buses. The dotted lines represent the fault-bus connections. If a fault occurs on the line bus marked (*x*) the fault current will flow through the fault bus and current transformer and actuate relay 3 which will trip the four line switches and also the two group switches *A* and *B*, thereby

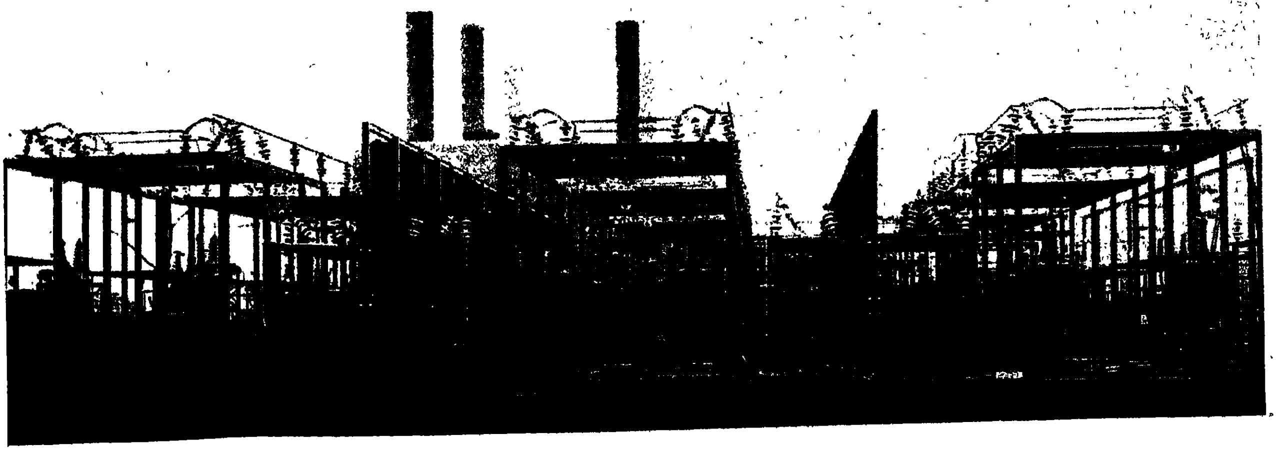


Fig. 4. Outdoor 66-kv. switching terminal at Calumet generating station. Note isolated-phase construction and high screen barriers between phase groups

isolating the fault. For faults between two unit groups, time sequence relaying is employed to prevent unnecessary switch-openings. For instance, if a fault occurs on switch *E*, relay 4 will first trip the line and group switches; and if the fault is not cleared within 0.7 sec., relay 7 will trip all switches connected to the red main bus section where switch *E* is connected.

Fault buses are now installed in all new generating stations, distribution stations, 66-kv. terminals and some of the larger substations to protect against bus and equipment failures.

DIFFERENTIAL RELAY PROTECTION FOR GENERATORS AND LARGE TRANSFORMERS

A differential method of relaying is employed to disconnect faulty generators and 66-kv. transformers from the system. For generator protection the simple conventional scheme with a sensitive relay is used. For three-winding transformers, however, this simple arrangement cannot be used, especially where one or two windings are equipped for tap changing under load. Further difficulties are encountered because of the 30-ohm neutral resistance in the 66-kv. system; consequently, one set of relays is connected differentially across all three windings. (See Fig. 6.) These relays are of the *percentage differential* type; that is, they will trip when the tripping current exceeds a predetermined percentage of the load current. (See "Percentage-Differential Transformer Protection," p. 361, May 1931 issue of ELECTRICAL ENGINEERING.) On account of the tap-changers, this percentage for these relays must be relativly high, a value of 50 per cent being used. For faults on the 66-kv. winding close to the neutral, because of the neutral resistor limiting the fault current, a more sensitive relay is required. A second set of differential relays, connected across the 66-kv. winding, and with a setting as low as from 2.5 to 5.0 per cent, is therefore provided. In addition to the differential relays, ordinary overload relays are installed on the 12-kv. side of main and regulating transformers.

PILOT-WIRE RELAYING FOR TIE-LINE PROTECTION

As shown in Fig. 1 the 66-kv. tie lines between generating stations are connected to buses at the transmission terminals, these buses being divided into several sections and operated split or tied together depending upon the system requirements. The best way known to isolate instantaneously a faulty line on this type of system is the pilot-wire-relay scheme. This system, while rather costly, is justified by the size of the lines and the importance of the service. A three-phase scheme is employed with four pilot wires, pilot transformers, balancing resistors, and capacitors. It has been found that the capacitors can be omitted in the Chicago system, where the lines are all less than eleven miles long.

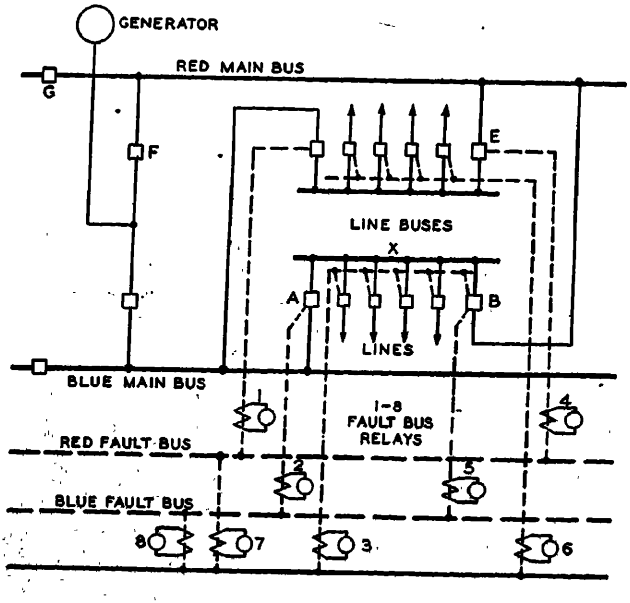


Fig. 5. Schematic diagram for typical section of fault bus

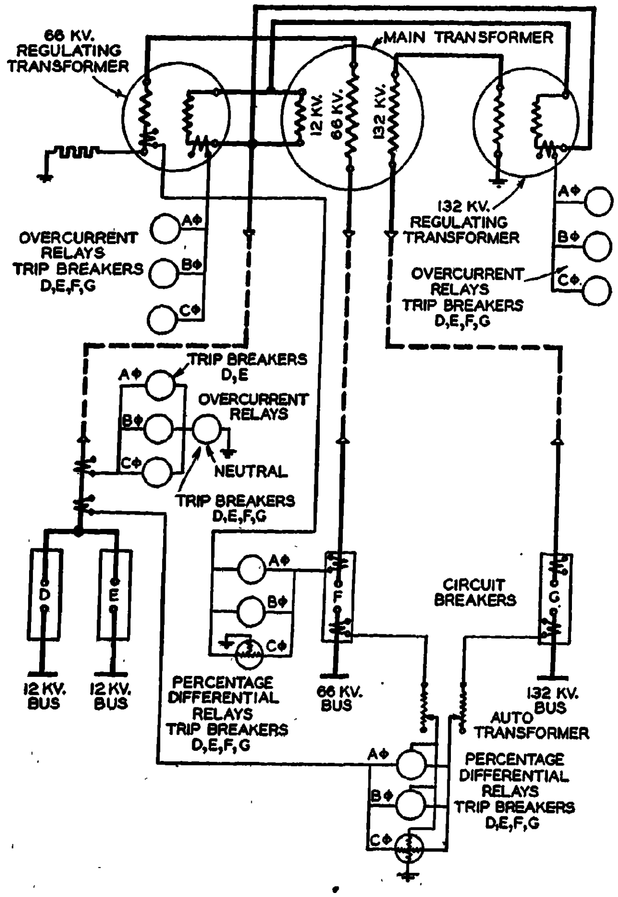

66 KV. REGULATING TRANSFORMER
MAIN TRANSFORMER
12 KV.
66 KV.
132 KV.
132 KV. REGULATING TRANSFORMER
OVERCURRENT RELAYS TRIP BREAKERS D,E,F,G
A⌀
B⌀
C⌀
TRIP BREAKERS D,E
OVERCURRENT RELAYS
NEUTRAL
TRIP BREAKERS D,E,F,G
D
E
F
G
CIRCUIT BREAKERS
12 KV. BUS
12 KV. BUS
PERCENTAGE DIFFERENTIAL RELAYS TRIP BREAKERS D,E,F,G
66 KV. BUS
132 KV. BUS
AUTO TRANSFORMER
PERCENTAGE DIFFERENTIAL RELAYS TRIP BREAKERS D,E,F,G

Fig. 6. Connection diagram of percentage-differential relays for protecting three-winding tap-changing transformers

SECTIONALIZATION

In addition to the usual protective schemes, there are in use on this system means for preventing the spread of trouble; these cannot be classed with protective devices. As previously mentioned, the 66-kv. system is divided into two parts which are normally operated as independent units, so that trouble on one-half cannot affect the other half, even should the protective devices fail. On the 12-kv. system, the stations also are separated into two or more parts for the purpose of preventing the spread of trouble. These two parts may be permanently separated through reactance, which will limit the flow of short-circuit current; or they may be operated normally tied together and automatically sectionalized by relays. Normally these sectionalizing relays will not interrupt any service but are intended to separate each section and its dependent lines into a number of self-sustained units. In this way, failure of protective devices on one of these units will not spread the trouble to the other units.

SUBSTATION AND 12-KV. LINE PROTECTION

The isolated-phase construction with fault-bus protection has been extended to some of the later and larger substations; in others, line relays are relied upon for the proper clearing of faulty buses. For line protection, ordinary overload directional and balanced differential relays are used.

Up to a few years ago, the systems so far touched upon would have been all that required consideration when planning reliable supply for a city like Chicago. Now, however, some of these stations are shut down part time and more efficient generating capacity outside of Chicago is depended upon for the supply. This energy is delivered over long overhead transmission lines and their protection becomes part of the problem of service security.

One great difficulty with overhead lines is their susceptibility to lightning—a problem not yet completely solved. Still another problem to consider when large amounts of power are transmitted over great distances is that of stability. Several means for increasing the stability of a line have been introduced, however, most common among which are, (1) increasing the speed of clearing faults; (2) providing high speed excitation; and (3) changing system connections.

CONCLUSION

Past progress toward the goal of perfectly reliable service has been along three principal paths; namely, (1) improving the individual units of equipment, (2) providing faster and more reliable isolating devices, and (3) designing the complete system so that the loss of individual parts may be tolerated. In the future the metropolitan system should make its greatest advances along the line of general system developments based upon the present high quality of equipment. Marked improvement in the reliability of long overhead lines with a high degree of exposure may be expected, particularly when the power delivered must meet the exacting standards of metropolitan service.

Magnetic "Iron" Perfected by Research

THIRTY years ago great quantities of iron were necessary in cores of electrical devices to prevent undue electrical loss. High temperatures caused magnetic deterioration of the metal. Even alloys of apparently constant chemical composition had varying magnetic properties. In view of this obstacle, progress in transformers of electrical currents was especially difficult.

Then came the first big improvement; Hadfield in England discovered silicon as an alloying element with iron. In 1903 silicon steel appeared there, and a little later here. This new steel cut losses in half. They were again cut in half by better mill practise and improved raw material. For the next decade further progress was slow, improvements small. Things had again reached an impasse.

About that time, an effort was made by the writer at the University of Illinois to make iron alloys of only the purest materials obtainable. For nearly sixteen years the research has continued; one of its main objects being to determine the properties of really pure iron, because iron is the basis of all important magnetic materials. Who would have believed that the elimination of a few thousandths of one per cent of carbon could be responsible for raising the maximum permeability of iron from perhaps 10,000 to 50,000 with corresponding decreases in hysteresis? Yet this has been amply demonstrated.

The work has been fraught with exceptional difficulties since it dealt with subjects like strain in the crystal structures, and with impurities in thousandths of one per cent. Furthermore, these very small amounts of oxygen, carbon, and sulphur exist in solution in solid iron—like sugar in solution in a glass of water.

Commercially, the most important results have come from the study of iron-silicon and iron-nickel alloys. Laboratory results are not rapidly translated into commercial practise. Five years after the first published results, no appreciable effect appeared in commercial steel. In 1920, after much discussion and many experiments, the steel mills began to put some of the

---

From an articl written by Dr. T. D. Yensen of the Westinghouse Research Laboratories for *Research Narratives*, Feb. 15, 1931, published by the Engineering Foundation, Inc., 29 West 39th Street, New York, N. Y.

findings into practise and there has since been a steady annual improvement in the quality of electrical sheet iron. Now the commercial material is almost as good as the laboratory product of a few years ago.

Hipernik (an alloy of half iron and half nickel) is another product of the laboratory. At first used in high-quality radio receiving sets where it contributed largely to the elimination of distortion of sounds in reproduction, it has gradually entered other important fields. In the near future we may find this alloy in many places where iron-silicon alloys are used today. Here again the difference between the ordinary alloy and hipernik cannot be ascertained by usual chemical analysis; radically new methods had to be devised.

(EDITOR'S NOTE: Under date of May 25, 1931, the American Rolling Mill Company, Middletown, Ohio, announced that this special alloy now is being rolled commercially from 6-ton ingots.)

Associates who have contributed to this success include G. H. Cole,[1] A. A. Frey, T. Spooner[2] and N. A. Ziegler. In its large practical results, this long and painstaking research is a vivid example of how the affairs of men are affected by scientific work which only a few years ago would have appeared hopelessly theoretical.

Overseas Radio Telephone Service

More than four years have elapsed since the installation of the first transoceanic radio-telephone circuit between New York and London. Some of the more recent developments in this class of service are discussed here.

By
F. A. COWAN
Member A. I. E. E.

American Tel. & Tel. Co., New York, N. Y.

SHORT-WAVE RADIO has played an important part in the extension of the telephone frontiers beyond the boundaries of this North American continent. During the four years which have elapsed since the first commercial telephone service between this country and Europe was inaugurated all of the world's overseas telephone extensions have employed short-wave radio. With the exception of the original New York-London circuit which operates on 1,500 m., the wavelengths used have ranged between 14 and 100 m. Today there are three short-wave circuits between New York and London supplementing the original long-wave circuit. In addition to these there is a circuit between New York and Buenos Aires, Argentina, circuits from New York to ships at sea, and one from London to Sidney, Australia (See Fig. 1). All of these circuits are available to telephone users in this country, and in addition to these facilities, extensions are being planned between New York and Hamilton, Bermuda, New York and Rio de Janeiro, and San Francisco and Honolulu, Hawaii. Since such factors as susceptibility to noise in transmission across equatorial regions, and the character of other transmission variables, including economic considerations, favor the use of short *vs.* long waves, all of these circuits will employ short-wave radio.

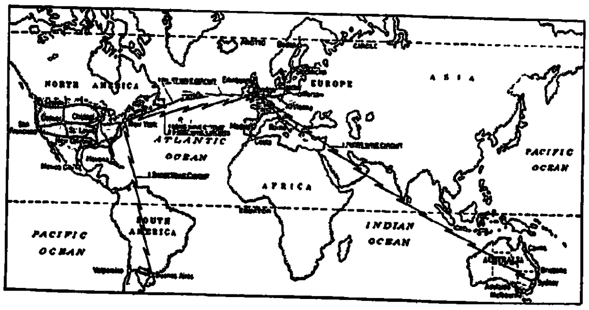


Fig. 1. Radio links between telephone systems of North America and other countries

NEW YORK-BUENOS AIRES CIRCUIT

A schematic layout of the New York-Buenos Aires circuit may be seen in Fig. 2. A crystal-controlled high-powered transmitter employing water-cooled vacuum tubes with an output of between 15 and 20 kw. is employed at both terminals. Associated with this transmitter are directive antennas which increase the signal strength by an amount equivalent to a 20- to 50-fold increase in transmitted power. Upon leaving the transmitting station, signals travel by the well-known sky-wave route to the foreign terminal. Radio receiving stations of the double-detection type equipped with automatic gain control and directive antennas are employed. To care for the changing transmission conditions these directive antennas are provided for three separate wavelengths. The received speech signals are transmitted from the receiving station to the foreign subscriber over land lines.

These directive-antenna arrays improve the receiving conditions by strengthening the signal received from the selected direction, reducing the effect of noise and other

---

From "Recent Developments in the Operation of Radio Telephone Service," (No. 31-57) presented at the A. I. E. E. Middl Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

[1] Member '27. [2] Fellow '29.

signals coming from other directions. The automatic gain-control feature compensates for moment-to-moment variations in the strength of the received carrier wave and when radio noise conditions are satisfactory the complete receiving system is capable of satisfactorily utilizing a signal having a field strength as low as one microvolt per meter. This performance has been made possible by the selection of a receiving site sufficiently isolated to minimize local interference, and by the careful design of the component parts of the receiving system.

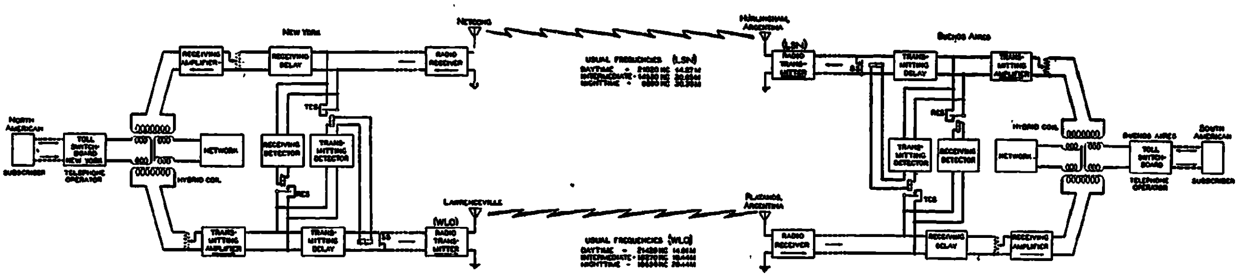


Fig. 2. Schematic layout of New York-Buenos Aires radio-telephone circuit

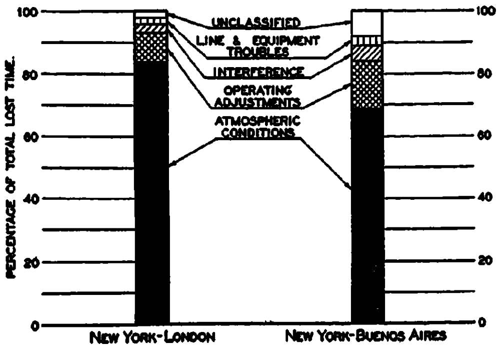


Fig. 3. Analysis of time lost on two short-wave radio-telephone circuits for a typical summer month

At the terminal points voice-operated-relay switching equipment disables the radio path in one direction while speech is traveling in the opposite direction. It also maintains the transmitting side of the circuit in a disabled condition when no speech is being transmitted. This automatic switching simplifies the transmission problem by resolving the two-way circuit into two one-way circuits. The switching-relay circuits are carefully adjusted to compensate for any changing transmission conditions, thus minimizing interruptions due to false operation of the relays.

Once the circuits of the type under consideration have been established their performance is controlled largely by the condition of the transmitting medium at any particular time. Since the control of this medium is beyond the scope of human endeavor, the operating problem becomes one of maintaining the component parts of the system in good condition and operating the system as a whole to best advantage.

LOST CIRCUIT TIME ANALYZED

A comparative analysis of the lost circuit time for a typical summer month on the New York-Buenos Aires circuit and one of the New York-London short-wave circuits, is shown in Fig. 3. It may be noted in each case that the major percentage of lost time is due to atmospheric conditions.

Whereas normally the conditions are good, there are times when, due to some disturbances of a nature not clearly understood, radio transmission from certain paths is seriously affected. These disturbances have been correlated reasonably well with abnormal activity in the magnetic field of the earth and are commonly known as "magnetic storms."

These occur at irregular intervals and at times result in reducing the signal strength at the receiving points to unusable values. Transmission on all frequencies is affected to a greater or lesser degree, and the time in each 24-hr. period during which reliable transmission can be expected is materially reduced. This interference usually is seriously effective for several days preceding and following the day on which the storm is actually at its height.

The equipment used in the short-wave radio circuits is so designed and constructed as to minimize the likelihood of trouble. In addition, spare units of equipment have been provided for replacing equipment which would be most subject to trouble or which would require considerable time to repair. These precautions, together with a systematic testing routine, account for the small amount of lost time due to equipment troubles.

In view of their adaptability to transmission over great distances and the rapid progress that is being made in improving, simplifying, and reducing their cost, short-wave radio systems are of outstanding importance in the development of world-wide telephonic communication. What the future will bring can only be guessed; but it does seem reasonably certain that for the next few years the short-wave circuits will continue to occupy a prominent position in the forward march toward the development of a world-wide telephone service.

That the concerted efforts of power companies and electrical manufacturers to combat the disturbing influences of lightning already have borne fruit, is attested by the greatly reduced transmission line outages from this cause. Results of recent investigations in this field as described in twelve Institute papers form the basis for the six articles which follow.

Theoretical Studies Laboratory and Field Tests Operating Experiences Lead to Effective System Protection Against

THE LIGHTNING PROBLEM as it affects the operation of electric light and power systems, according to Sporn logically divides itself into three parts:

1. Theoretical and laboratory investigations which include mathematical studies and various analyses of lightning phenomena.
2. Field research with natural and artificial lightning, which studies are enhanced from year to year by developments and improvements in equipment.
3. Evaluation of the effects of different devices and of line design upon the mitigation of lightning disturbances by the study and analysis of practical operating records.

This and the five articles following in this issue of ELECTRICAL ENGINEERING present a collection of theories and facts relating to these different aspects of the lightning problem. These articles have been prepared from twelve Institute papers (see Table I) of which three treat mainly the theories involved in lightning studies; two deal entirely with field investigations of surges imposed on transmission systems by means of artificial lightning discharges; four present the results of field investigations of natural lightning discharges; one gives the results of analysis and interpretation of a large quantity of operating data collected on systems in service; while one is devoted to a description of a new device designed to protect line insulators against flashovers.

An attempt has been made to correlate information from these different sources, outlining in some detail the most recent findings in this important field, and indicating the relation between these latest disclosures and previously accepted ideas. Additional information has been obtained quite recently regarding the mechanism of lightning formation and discharge, and some new theories have been advanced. It is realized generally, however, that present ideas still are entirely inadequate for a thorough understanding of the fundamental nature of lightning. Nevertheless, in spite of the obscurities, several important disclosures have been made. These are outlined in the paragraphs that follow and are based upon the results given in the entire set of twelve papers.

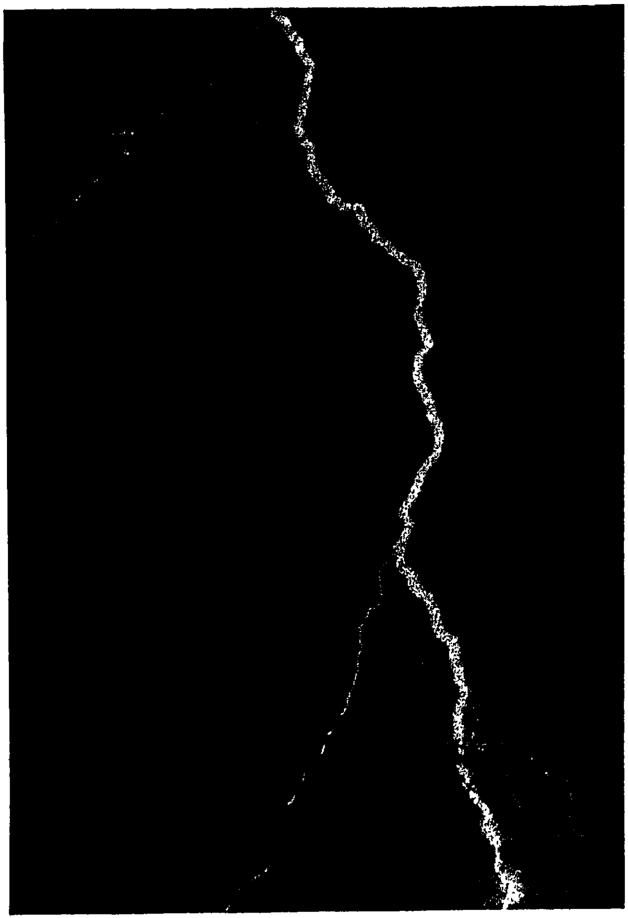
Concerted action in theoretical and field studies of natural and artificial lightning phenomena received its first great impetus in 1926 with the appointment of the lightning subcommittee of the A. I. E. E. transmission and distribution committee. This subcommittee was established primarily to assemble more definite information regarding the nature and characteristics of lightning and related electric system disturbances; also to ascertain possible protective measures with which to combat the troublesome disturbances. A general pooling of efforts and equipment followed, various utilities and the principal equipment manufacturers cooperating in practically all of the investigations subsequently carried out.

A paucity of suitable instruments hindered early work, the well-known klydonograph being practically the only instrument available. With that instrument it was possible to ascertain some idea as to the magnitude of lightning voltages, but the extremely short duration of such discharges made extremely difficult their accurate study with apparatus having mechanical recording elements. Development of new instruments and their liberal use, and the concentration of major field efforts upon a relatively few representative systems have been the two factors chiefly responsible for the rapid acceleration of lightning studies during 1929 and 1930.

DIRECT HITS AND INDUCED SURGES

Line surges can be very harmful whether due to direct hits or to induction from cloud discharges or strokes to nearby objects. It is generally recognized, however, that disturbances arising from direct strokes to line conductors or to ground wires on well grounded steel structures, subject lines to more severe punishment than do induced surges in general. The induced surge appears to be of minor importance on lines as highly insulated as are the 220-kv. lines in eastern Pennsylvania and New Jersey. Of course, voltages also can be induced on the conductors when a direct hit on the tower or ground wire occurs. Whether or not these induced voltages will cause a flashover appears to depend upon line insulation and tower footing resistance.

Lightning Disturbances



Westinghouse E. & M. Co. Photo

WAVE SHAPES

Wave shapes of lightning surges depend upon many varying factors, chief among which are the origin of the surge (whether induced or due to a direct stroke), duration of cloud discharge, and cloud height. Some of the many cathode-ray oscillograms which have been taken both of induced surges and direct strokes are reproduced in this symposium. Wave fronts varying in length from 2 to 9 microsec. with length of tail to half-voltage of from 6 to 40 microsec. have been observed. The total lengths of these waves vary from 10 to 160 microsec. In an oscillogram of a direct stroke estimated as terminating on the line 125 ft. from the laboratory, a voltage rise of 1,540 kv. per microsec. was recorded (see Fig. 16). Most of the oscillograms, however, were obtained at some distance from the point of incidence and, therefore, do not show the true wave shape at that point, having suffered distortion in traveling along the line.

Negative surges have steeper fronts than do those of positive polarity. It has been estimated that the former may have fronts as short as 1 microsec. or less, while the probable minimum for the latter is approximately 5 microsec.

ATTENUATION, DISTORTION, AND REFLECTION

Traveling waves arising from lightning discharges undergo a continuous change as they proceed along the line, the general tendency being a slowing down of the front, a flattening of the tail, and a general increase in total length. Corona appears to be the greatest cause of this phenomenon; hence it follows that the reduction in wave crest is more rapid above than below the critical corona voltage. Attenuation is more rapid for extremely high-voltage surges and according to indications may be as high as 1,000 kv. per mi. of travel.

Surges impressed upon three parallel conductors evidence a more rapid slowing down of front but lower rate of attenuation than do waves on a single conductor. Reflections from line sections of changing impedance and from terminal equipment also are factors in wave shape change; characteristics of these reflections can be predicted by means of "lattice" diagrams.

CREST VOLTAGES AND CURRENTS

The maximum voltage recorded in any of the tests described was 5,000 kv., measured on a wood pole line at a point about 4 mi. from the point of incidence of a direct stroke (see Fig. 21). Indications are that the voltage of a direct stroke may be as high as from 10,000 to 15,000 kv. A maximum discharge current of 670,000 amperes was reported, determined by adding together the tower ground currents for the several towers affected. This method may be subject to some errors; its merits are a controversial matter. Other indications, however, also point to a maximum of several hundred thousand amperes.

POLARITY

No definite conclusions have been drawn in regard to polarity, but it seems well established that both positive and negative cloud potentials exist. However, more di-

Table I—Identification Data Pertaining to Lightning Papers Abstracted in This Group of Articles

Authors names	Company affiliations	Pamphlet copy titles	Serial numbers	Presented at	Dates presented
Edgar Bell Associate A. I. E. E. **A. L. Price** Associate A. I. E. E.	Penn. Pwr. & Lt. Co., Hazleton, Pa. Penn. Pwr. & Lt. Co., Hazleton, Pa.	Lightning Investigation on the 220-Kv. System of the Penn. Pwr. & Lt. Co. (1930)	31-89	District meeting, Rochester, N. Y.	April 29–May 2, 1931
L. V. Bewley Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Traveling Waves on Transmission Systems	31-4	Winter convention, New York	Jan. 26–30, 1931
Otto Brune Associate A. I. E. E. **J. R. Eaton** Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass. Consumers Pwr. Co., West Jackson, Mich.	Experimental Studies in the Propagation of Lightning Surges on Transmission Lines	31-85	District meeting, Rochester, N. Y.	April 29–May 2, 1931
J. C. Dowell Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Attenuation and Successive Reflections of Traveling Waves	31-42	Winter convention, New York	Jan. 26–30, 1931
C. L. Fortescue Fellow A. I. E. E. **R. N. Conwell** Fellow A. I. E. E.	West. Elec. & Mfg. Co., Pittsburgh, Pa. Pub. Serv. Elec. & Gas Co., Newark, N. J.	Lightning Discharges and Line Protective Measures	31-82	District meeting, Rochester, N. Y.	April 29–May 2, 1931
I. W. Gross Associate A. I. E. E. **J. H. Cox** Associate A. I. E. E.	Am. Gas & Elec. Co., New York West. Elec. & Mfg. Co., E. Pittsburgh, Pa.	Lightning Investigation on the Appalachian Elec. Pwr. Co's. Transmission System	31-86	District meeting, Rochester, N. Y.	April 29–May 2, 1931
W. W. Lewis Member A. I. E. E. **C. M. Foust** Associate A. I. E. E.	Gen. Elec. Co., Schenectady, N. Y. Gen. Elec. Co., Schenectady, N. Y.	Lightning Investigation on Transmission Lines—II	31-87	District meeting, Rochester, N. Y.	April 29–May 2, 1931
F. W. Peek, Jr. Fellow A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Lightning, Characteristics — Induced Voltages—Direct Strokes—Coordination — Transmission Line Design	31-88	District meeting, Rochester, N. Y.	April 29–May 2, 1931
R. R. Pittman Associate A. I. E. E. **J. J. Torok** Associate A. I. E. E.	Ark. Pwr. & Lt. Co., Pine Bluff, Ark. West. Elec. & Mfg. Co., East Pittsburgh, Pa.	Lightning Investigation on a Wood Pole Transmission Line	31-10	Winter convention, New York	Jan. 26–30, 1931
Philip Sporn Fellow A. I. E. E.	Am. Gas & Elec. Co., New York	1929 Lightning Experience on the 132-Kv. Transmission Lines of the Am. Gas and Elec. Co.	31-20	Winter convention, New York	Jan. 26–30, 1931
Philip Sporn Fellow A. I. E. E. **W. L. Lloyd, Jr.** Member A. I. E. E.	Am. Gas & Elec. Co., New York Gen. Elec. Co., Pittsfield, Mass.	1930 Lightning Investigations on the Transmission System of the Am. Gas and Elec. Co.	31-79	District meeting, Rochester, N. Y.	April 29–May 2, 1931
J. J. Torok Associate A. I. E. E.	West. Elec. & Mfg. Co., E. Pittsburgh, Pa.	An Experimental Lightning Protector for Insulators	31-9	Winter convention, New York	Jan. 26–30, 1931

rect strokes of negative polarity have been recorded than those of positive polarity, while the majority of induced strokes appear to be positive. The question of polarity is important inasmuch as negative strokes have been observed to have steeper wave fronts, while positive polarity surges attenuate more rapidly.

EXTENT OF SYSTEM AFFECTED

Flashovers have occurred in the majority of cases on only one phase, but usually involve corresponding insulator assemblies at two or more adjacent towers. Evidences of direct-stroke currents have been observed in as many as five or six towers. On highly insulated ungrounded lines, such as the wood pole line previously mentioned, traveling waves of dangerous magnitude may reach substation equipment and cause flashovers there, since such equipment in general is less highly insulated than the line equipment. Under these conditions, especially good lightning arrester equipment is required at the stations. On well-grounded steel tower lines where flashovers do not occur, severe electrical disturbance usually is limited to a few structures, and any surge propagated over the conductor will be of extremely low magnitude.

FLASHOVERS AND TRIP-OUTS

Flashovers from direct strokes may occur if (1) the stroke terminates on the line conductor; (2) the stroke terminates on a tower of high surge impedance, thus raising the tower potential with reference to the conductor; (3) the stroke terminates on the ground wire between towers and the potential is of sufficient magnitude to cause flashover at that point, in which case flashover at an adjacent tower is certain to occur.

Experience has shown that direct strokes may occur at towers of low footing resistance without subsequent flashover. Whether or not a trip-out will result when flashovers occur depends upon whether the amplitude and polarity relations of line voltage and current are such as to permit the establishment of a power arc at the time of flashover. That flashovers can occur without causing line trip-outs is definitely shown by records of a lightning surge of 2,500 kv. which did not cause a trip-out but which most certainly did cause a flashover.

Induced surges also may cause insulator flashovers with resultant line trip-outs, especially when direct strokes occur to nearby objects. The likelihood of these surges reaching flashover value, however, is minimized by the installation of conventional overhead ground wires.

Effects of Grounding

Beneficial effects of overhead ground wires have been proved without doubt both by special investigations and operating experiences. Operating experiences have shown also that two ground wires are much more effective than one alone. The effectiveness of ground wire protection depends to some extent upon tower footing resistance; where this is high, special grounding cables or counterpoises can be used effectively to lower the surge impedance of the structures. Counterpoise cables are most effective when extended out radially from the tower foot, but in practical cases are restricted by right-of-way limitations to the two directions along the line. Operating experiences show, however, that flashovers do not always concentrate at towers having high footing resistance.

Line Design

General requirements for good lightning protection are low lines, short spans, low tower footing resistance, and overhead ground wires. The number and position of overhead ground wires will depend upon the conductor configuration and the number of circuits. Spacing between conductors and ground wires must be large in order to prevent flashovers at mid-span.

For effective protection against direct strokes the tower footing resistance should not be more than 4 or 5 ohms. Where this is impractical special overhead ground wire structures, known as diverters, may be installed if the economics of the situation permit.

Protective Devices

Lightning arresters are especially applicable at substations to protect terminal equipment against lightning damage. The principal qualification is that they be placed reasonably close to the equipment they are designed to protect. Arresters also are used on transmission lines where provision cannot be made economically for the installation of overhead ground wires.

In this connection field investigations have shown that arresters of the expulsion type will successfully interrupt dynamic current follow-up. A promising new device now under development consists of a hollow fiber tube with electrodes at either end, wherein the breakdown element is the air contained in the tube. Grading shields have not been found to decrease the number of line outages, but, when properly installed, they do minimize the damage to insulators, line hardware, and conductors, and reduce the amount of cascading required.

Theories of Lightning Discharge and Traveling Waves

Recent theoretical findings concerning lightning and traveling waves are discussed in this article. When corroborated by field tests, these results furnish information from which a systematic scheme of protection can be established. "Direct-hit" wires above ordinary "sky wires" are suggested and discussed.

LIGHTNING may cause abnormal voltages on power transmission lines in either of two different ways—by direct stroke or by induction. Some understanding of the formation of these surges is necessary before a systematic scheme of protection can be evolved.

According to Fortescue and Conwell the thundercloud consists of small particles of water-vapor, each carrying a minute charge of electricity, free negative charges attaching themselves to the vapor particles. Since the mobility of the resulting charged moisture particles is very small the only way in which a discharge can take place is through ionization. This ionization process results in the formation of a lightning streamer.

Some streamers will never reach the earth because of an insufficient charge in the cloud. This would indicate that lightning disturbances resulting from streamers which do reach the earth will vary somewhat in severity over a wide range, depending upon the amount of energy which the cloud is capable of discharging. The energy in the streamer itself is mainly potential energy until the earth or a structure is reached, when its potential energy is changed instantly into kinetic energy in the form of a current wave moving at the velocity of light into the earth or structure through the path pioneered by the streamer. Negative reflections pass up the same lightning channel, increasing the discharge current and also the gradient in the cloud. This in turn tends to extend more streamers throughout the cloud until the available energy is decreased below the point necessary to maintain the lightning channel.

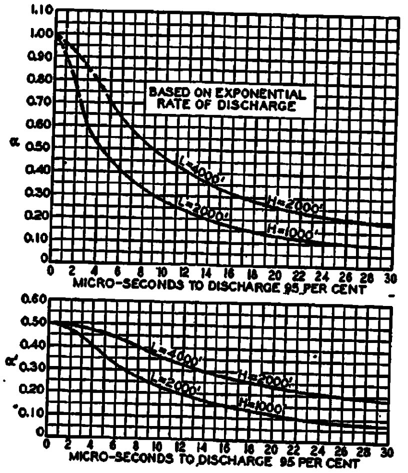


Fig. 1. Values of α for calculating lightning voltages induced on transmission lines (exponential rate of discharge assumed)

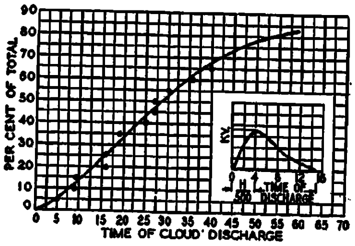


Fig. 2. Duration of cloud discharges determined from cathode-ray oscillograms

Complete data on the limiting value of lightning stroke potentials are not yet available but fairly good approximations for potentials ordinarily encountered may be made. Since voltages may be caused either by direct strokes or by induction, it is of practical importance to be able to estimate the numerical values of these voltages under both conditions.

Direct Strokes

Peek discusses the question of direct lightning strokes from the theoretical aspect and arrives at several interesting conclusions. The chance of a line being struck by a direct bolt increases of course with increasing height of line. On a flat plane without projections, a tower may be hit when the distance from it to the projection of the storm center is less than from four to ten times tower height. This factor is based upon the assumption that the nearest object will be hit and has been called the direct-hit ratio.

Where lines are brought through a right-of-way with nearby trees practically equal in height to the line, the hazard of direct strokes reaching the line should be very small. It has been found that a tree can direct or attract a lightning stroke as readily as can a metal tower because the charging takes place with low current and over a relatively long time. Also it has been found that the chance of any particular tower being struck does not depend upon its footing resistance, but that the resulting voltage on line insulators following a hit does depend almost entirely upon such resistance.

As a rule, a tower is more likely to be struck than the line. When this occurs the resulting voltage between line and tower, or ground wire, or across the line insulator string, is given by the formula

$$V_e = K I R$$

where K is a constant depending upon the tower and ground-wire configuration, I is the tower current (which will be less than the total-stroke current by the current flowing in the ground wire), and R represents the tower footing resistance. Fairly accurate approximations can be made by assuming $K = 0.8$. The importance of keeping the tower footing resistance low is obvious from the above formula if immunity from direct-stroke sparkovers is to be obtained.

As an example, it can be shown that on a line insulated with 14 disk insulator units, a tower resistance of 40 ohms would result in a voltage of 3,200 kv. on a 100,000-ampere direct bolt. In order to keep the voltage below sparkover value of this line the tower resistance must not exceed 20 ohms. For higher discharge currents the tower resistance must be correspondingly lower to prevent the establishment of sparkover voltages.

Induced Surges

When voltages occur by induction their polarity is opposite to that of the cloud source and their numerical values may be calculated by the formula

$$V = G h \alpha$$

where V is the voltage above ground, G is the potential gradient in volts per foot (100,000 is the accepted maximum value), h is the line height in feet, and α is a factor depending upon the duration of cloud discharge and the distribution of bound charge. Values of α calculated on the basis of an exponential rate of cloud discharge may be seen in Fig. 1. Since an instantaneous cloud discharge is impossible, α always will be less than unity. As plotted in Fig. 1 α is the factor to be used in computing maximum potentials at the point of origin while α' is the factor for computing the crest voltage on the resulting traveling wave.

That the distribution of bound charge affects the shape of the traveling wave to a much less extent than does the law of cloud discharge had been determined previously. The bound charge therefore can be assumed to be rectangular without involving any marked departure from the true shape of the traveling wave. Cathode-ray oscillograms are especially useful in determining the shape of traveling waves. If taken reasonably near the source and not badly distorted by sparkovers, losses, or reflections, they give practically the complete life history and characteristics of the stroke. In oscillograms of this nature the time from zero to crest voltage gives a measure of the length of bound charge, while the time from crest to zero on the falling part of the wave is the duration of cloud discharge. In addition the equivalent distance for one-half the time to crest approximates the height of the cloud. These ideas regarding the origin and characteristics of induced surges are concurred in by both Bewley and Peek.

Bewley points out, however, that as the time of cloud discharge increases, both α and α' (Fig. 1) decrease and rapidly approach equality for discharges slower than 10 microsec. He has computed also that for an average line height of 60 ft., and a 3,000-ft. rectangular bound charge (allowing 10 microsec. for the cloud discharge) the maximum voltage for induced traveling waves is somewhat less than 2,000 kv. A similar computation by Peek agrees with this value. It is evident that high-potential induced surges are possible only with very short waves and that for cloud discharges of long duration induced surges become quite harmless.

Peek, in discussing further the relations between traveling waves and cloud characteristics, states that information can best be obtained by cathode-ray oscillograph measurements made in the field. When the waves become distorted, however, the front no longer is of value in obtaining information on cloud height or length of bound charge because the values would be too high. The lengthened tails on such distorted waves indicate a longer duration than actually obtained. A good approximation, however, is that the duration of discharge is twice the time from crest to half voltage on the tail part of the wave. Since due to reflections a wave may persist for a number of loops, only the first loop is of interest for this approximation. Fig. 2 shows the results of a large number of such oscillograms where the crest voltages were higher than 100 kv. and line sparkover did not occur.

When the time and manner of discharge have been determined the lightning discharge current also can be ascertained mathematically. However, since these currents appear quite large (400,000 amperes for a typical case) confirmation by actual field measurements is necessary before final conclusions can be drawn.

General Properties of Traveling Waves

Bewley continues his theoretical study of traveling waves as outlined briefly in the following paragraphs.

The behavior of an n-conductor system having mutual inductance and capacitance between conductors can be formulated by a partial differential equation of the $2n$ order in both time and space derivatives. Although a formal solution for such an equation exists, it is too complicated to be of much use from an engineering point of view. However, solutions for (1) a no-loss system, (2) a completely transposed system, and (3) the steady-state alternating-current condition, are easily obtained.

If a line is free from losses the differential equations of the system are satisfied by pure wave functions. If the line is completely transposed so that every conductor occupies the same relative position as every other conductor, and for the same distance, then the possible average velocities between terminals are reduced to two in number. The conventional method of calculating the steady-state alternating-current behavior of a transmission line by using constants to neutral is a very special case, but is rigorous for a single-circuit, three-phase, completely transposed line.

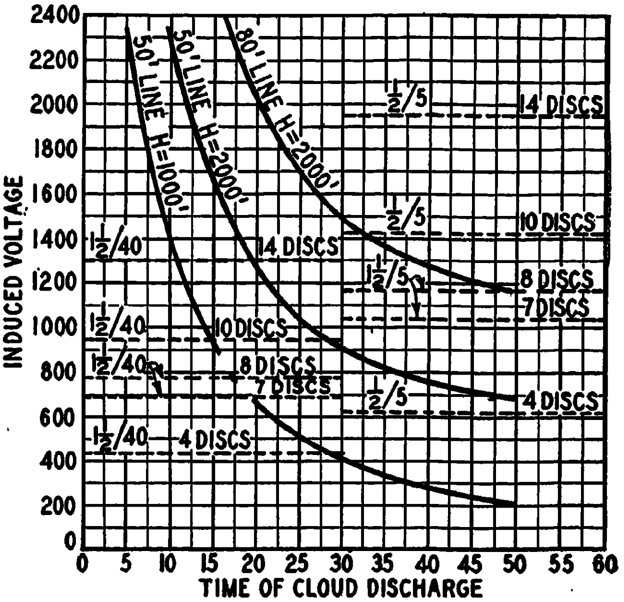


Fig. 3. Induced voltages on 50- and 80-ft. lines for different cloud-discharge durations and two cloud heights

For free traveling waves on a multi-conductor system, the energy is equally divided between the electrostatic and electromagnetic fields. However, when waves moving in the opposite direction pass through one another (as occurs from reflections at transition points) the energy balance is upset so that the energy resides more in one form than in the other. Pure traveling waves, which can occur only in a no-loss circuit, in general have as many possible velocities of propagation as there are conductors in the circuit. When the conductors are overhead wires these velocities all reduce to the velocity of light.

The behavior of traveling waves at general transition points (see Fig. 4) can be determined by a system of simultaneous equations involving the reflection, refraction, and transfer operators of the circuit. By a fortunate coincidence these can be expressed by one or the other of two equations containing only three parameters. In solving for different terminal conditions, therefore, it is necessary merely to tabulate the values of the three parameters for different cases with reference to the proper equation. Thus a large mass of information can be condensed into a relatively small space.

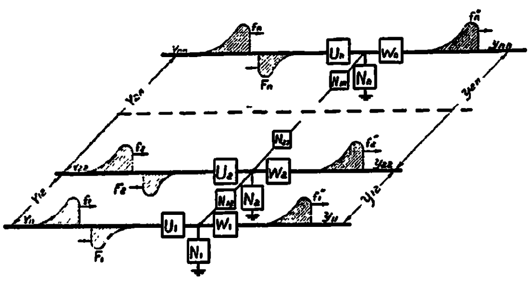


Fig. 4. Incident- and reflected-wave relations on a multi-conductor system

Typical Shapes of Traveling Waves

The principal shapes of most natural waves may be represented by the difference of two exponentials, the actual waves of course being serrated by minor irregularities. The cathode-ray oscillograph has proved its usefulness in investigating this phase of the problem, and during the past few years many oscillograms of natural lightning waves have been obtained under widely varying conditions. These have provided fairly definite information as to the general shape and characteristics of such surges. In calculating the effects of traveling waves, therefore, these characteristics must be kept in mind so that the influence of fronts, tails, and lengths of the waves may be evaluated. Three different methods for calculating waves of arbitrary shape are given by Bewley as follow:

1. Express in operational notation, combine with the function representing the reflection or refraction operator, and solve the resulting operational equations.
2. Consider the wave as made up of a series of infinite rectangular waves, adding the solutions corresponding to each component rectangular wave.
3. Express the wave as the sum of several functions for which the individual solutions are known or can be found, and add these solutions.

Each of these methods is subject to certain advantages and limitations. With the first method the operational equations usually are so complicated that a solution either cannot be obtained at all, or only by the most laborious and complex process. The second method is only an approximation, of course. In a great many cases, however, it is sufficiently accurate and has the advantage of simplicity especially where the incident wave is greatly complicated.

The third method, in which the wave is represented as a sum of functions for which the solutions are known, is quite useful and practicable. By properly compounding a few simple functions almost any desired wave shape can be reproduced with a fair degree of approximation. This process is illustrated for a few typical cases in Fig. 5 where the elementary waves considered are (1) infinite rectangular, (2) simple exponential, (3) uniformly rising front, (4) damped sinusoid, and (5) difference of two exponentials.

Attenuation and Distortion

Bewley continues that it usually is justifiable and convenient to perform traveling-wave calculations on the assumption of no losses, and then to compensate for attenuation by an exponential decrement factor determined experimentally. Corona, it is generally agreed, is the chief cause of attenuation and distortion. It levels off the top and elongates the wave, but its effect is somewhat variable depending upon the weather and other conditions.

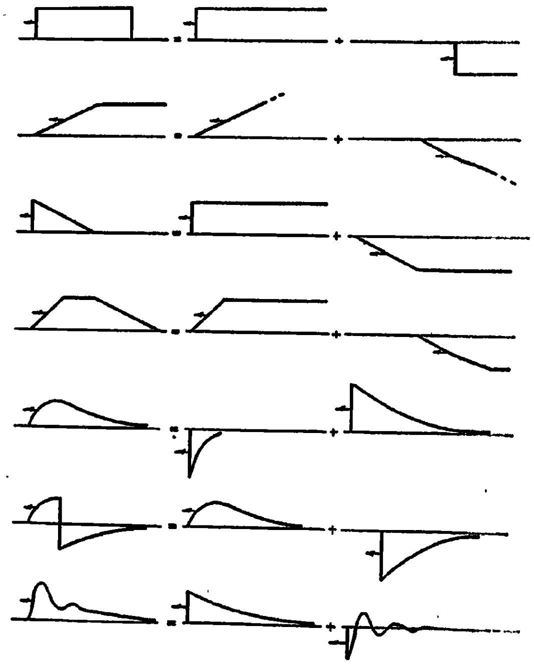


Fig. 5. Separation of complex waves into two simple waves

Effects of line losses are threefold; (1) voltage and current waves are attenuated, (2) wave shapes are distorted with time, and (3) the waves depart from exact similarity, so that the simple linear proportionality factors (called the surge impedances) and the linear equations cease to hold except as approximations. Skin effect and normal line losses, according to Bewley, are of minor importance and may be neglected in comparison with corona losses.

Brune and Eaton in discussing the theoretical aspects of their line tests state that the very front of the wave suffers the greatest attenuation (becoming less and less steep) the net result being that the entire wave is lengthened and the crest voltage is reduced. This is caused not only by corona, but also by skin effect and series resistance in the line. Attempts to calculate the effect of corona by assuming an equivalent "leakance," however, are stated to be erroneous, since the corona does not establish a conducting path by means of which charges may leak off the line except at voltages near sparkover values.

To clarify somewhat the mechanism of corona, Brune and Eaton explain that usually the area surrounding a conductor becomes conducting only within an envelope of limited radius, and as the voltage rises above the corona voltage, charges enter this envelope thereby decreasing the voltage on the front of the wave. Such charges will remain in the corona envelope as long as the conductor voltage is high; when it falls the charges return to the conductor thus tending to maintain the high voltage on the tail of the wave. In this exchange of charge between conductor and corona envelope energy is lost, but no charge.

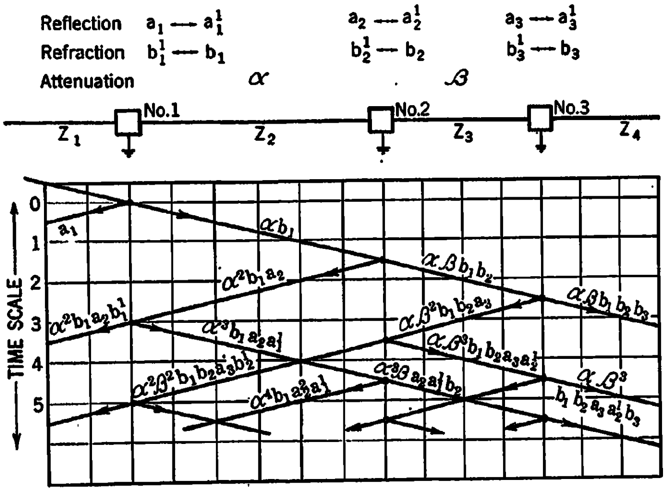

Reflection a_1 — a_1^1
a_2 — a_2^1
a_3 — a_3^1
Refraction b_1^1 — b_1
b_2^1 — b_2
b_3^1 — b_3
Attenuation
α
β
No.1
No.2
No.3
Z_1
Z_2
Z_3
Z_4
TIME SCALE
0
1
2
3
4
5
a_1
αb_1
$\alpha^2 b_1 a_2$
$\alpha\beta b_1 b_2$
$\alpha\beta b_1 b_2 b_3$
$\alpha^2 b_1 a_2 b_1^1$
$\alpha^3 b_1 a_2 a_1^1$
$\alpha\beta^2 b_1 b_2 a_3$
$\alpha\beta^3 b_1 b_2 a_3 a_2^1$
$\alpha^2\beta^2 b_1 b_2^2 a_3 b_2^1$
$\alpha^4 b_1 a_2^2 a_1^1$
$\alpha^3\beta a_2 a_1^1 b_2$
$\alpha\beta^3 b_1 b_2 a_3 a_2^1 b_3$

Fig. 6. Typical lattice diagram for computing successive reflections

Successive Reflections

In a number of important problems, such as in the theory of ground wire, the effect of short lengths of cable, and trunk lines tapped at short intervals, it is necessary to consider the effects of successive reflections of traveling waves. Difficulty sometimes is experienced in keeping track of such reflections where numerous reflecting points exist. To solve this difficulty lattice diagrams have been devised which show at a glance the position and direction of motion of every incident, reflected, and refracted wave on the system at every instant of time. In Fig. 6 a typical lattice diagram has been set up for a line containing three reflection points. These reflection points may consist of any combination of impedances in series with the line or shunted to ground. The circuits between these points may consist either of open lines or cables, and may have different surge impedances, velocities of wave propagation, and attenuation factors.

To construct such a lattice for any particular case it is necessary only to scale the junctions at intervals equal to the time taken by the wave to traverse each section between junctions. A suitable time scale then can be chosen (shown as the ordinate in Fig. 6) and the diagonals drawn in.

Reflection and refraction operators can be placed at the top of the lattice over the respective junctions with suitable directional indicators. These may be seen at the top of Fig. 6 where a and a' are respectively the reflection operators for waves approaching from the left and right, b and b' are respectively the refraction operators for waves approaching from left and right; α and β are attenuation factors for the sections between junctions. These operators, of course, are operational expressions involving the impedance functions of the junctions, but no restrictions are placed on their generality. Starting at the origin of the initial incident wave at the top of the lattice, the reflected and refracted waves at each junction can be obtained by applying the operators of that junction to the incident wave arriving there, then proceeding until the lattice has been completed. In these lattice diagrams it will be observed that:

1. All waves travel "down-hill."
2. The position of any wave at any time is determined from the vertical time scale at the left of the lattice.
3. The total potential at any point at any instant of time is the superposition of all the waves which have arrived at that point up to that instant of time, displaced in position from each other by intervals equal to the instants of their time of arrival.
4. The previous history of any wave is easily traced.
5. The effect of attenuation is included.
6. If it is desired to carry the computations to a point where it is not practical to place the various operators directly on the lattice itself, then

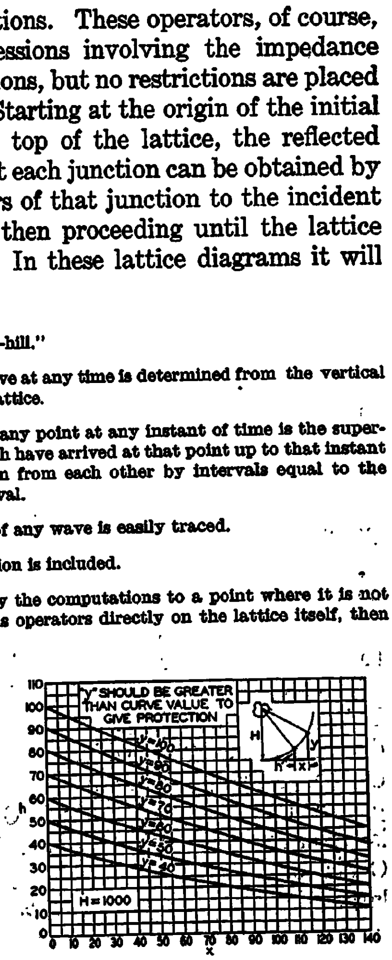


Fig. 7. Minimum ground wire heights (y) to shield line conductors against direct strokes from clouds 1,000 ft. above

the arms may be numbered and the operational expressions tabulated in a suitable form.

Dowell has used this method in analyzing the results of some of his investigations with artificial lightning impulses applied to typical sections of lines. These are treated in another part of this symposium.

OVERHEAD GROUND WIRES

To protect line conductors from direct hits the ground wire or wires should be at a sufficient distance above the line wires to "attract" the lightning. Peek has found that the shielding effect of ground wires depends not only upon their vertical height but also upon the horizontal distance between their projections and those of the line wires. Fig. 7 shows minimum values for the ground-wire heights required to protect the line wire against direct hits from a cloud 1,000 ft. above the earth. The respective heights for the line and ground wires are represented by h and y, and the horizontal distance between by x.

While this position for the ground wire may shield the line wire from the initial hit, it does not protect against side flashes or sparkovers from a struck ground wire to a line wire, where the hit takes place at some distance from a tower.

Hazards due to direct hits of this nature can be reduced by special provision in ground-wire design and tower spacing, but usually these are considered unnecessary since the chance of a hit between towers is small.

Even with ground wires installed, however, immunity from outages due to direct hits can be approached only with low tower footing resistance to maintain low tower potentials, and with heavy line insulation. In some cases in addition to the overhead ground wires with which lines now usually are equipped, "direct-stroke" wires strung above the ground wires may be necessary to prevent flashovers from midspan hits. The advantageous effect of short span construction can be simulated by supporting the ground wire not only from the main towers, but also from intermediate towers interposed between the main towers. Low-footing resistance usually can be obtained by means of buried (counterpoise) wires connected to the tower legs. The adoption of such an expedient will be governed, however, largely by cost considerations.

In rocky and mountainous country where it is difficult to obtain low tower footing resistance special ground-wire construction or line shielding may be necessary. It is possible also to prevent outages by some form of device at the tower which would permit lightning to discharge freely to ground, but which would prevent power current from following. One such device which is operating successfully is the fused grading shield. Other devices have been brought out, but still are largely in the experimental stage.

LIGHTNING SURGES AND LINE CONSTRUCTION

Formation of line surges due to lightning strokes is analyzed by Fortescue and Conwell in accordance with the type of transmission construction used. Their two classifications are (1) wood pole lines and steel tower lines not equipped with ground wires, and (2) steel tower lines equipped with ground wires.

Considering first wood pole lines unprotected by ground wires or spill-over gaps, the potential attained by a surge before the structure breaks down may be very high. When the structure flashes over, the potential is reduced quickly to a value which depends upon the surge impedance of the conductor and of the wood poles and ground. Some simple calculations using accepted formulas and constants show that a stroke which would deliver a 15,000-kv. surge on a single line conductor will appear at 77 per cent of this value on all three line conductors when all three are struck. Under such conditions flashover to ground will occur immediately, but a potential of about 30 per cent of the original surge will still exist. In the case of steel towers without ground wires the surge potential of the conductor after flashover will be the same as that of the tower so that one insulator string only may be flashed over if the surge impedance of the tower is low. The likelihood of another flashover taking place at adjacent towers is dependent upon the intensity of the stroke and the impedance of the tower circuit where flashover first occurs.

Where ground wires are used on steel tower construction, assuming that the protection is adequate, flashovers still may occur if the line is inadequately insulated. When a bolt strikes the ground wire at midspan the resulting surge will travel to adjacent towers where part of it will be absorbed by the tower, part will continue on the ground wire, and part will be reflected. Flashovers may occur between the towers and one or more conductors, so that towers, ground wires, and affected conductors will assume the same potential. Flashover also may take place at midspan between conductors and ground wire; the conductor potential then will be of sufficient magnitude to cause an additional flashover at an adjacent tower.

In a well protected, well insulated line a stroke to the ground wire in midspan or to a tower is quickly reduced by reflections from adjacent towers and becomes of very small magnitude three spans distant from the point hit. Calculations indicate that where tower footing resistance is low, insulator flashover is not likely to occur. In all cases where flashovers do not occur either at midspan or at towers, potentials induced on the conductors by coupling will become negligible beyond the region of the disturbance. In such cases no surge will be propagated over the line to terminal apparatus and the line will continue to operate unaffected by the lightning stroke.

Field Tests with Artificial Lightning

High-voltage impulses simulating lightning surges can be impressed on a line at will, and now provide the most convenient means for studying the characteristics of such waves. Corona is found to be the greatest cause of wave attenuation and distortion; to a lesser extent, skin effect.

IN THE first class of field investigation described, high-voltage impulses were impressed upon the line and cathode-ray oscillograms taken at different points along the line. By comparing oscillograms of the original wave with those taken out on the line, information was obtained regarding the general behavior of traveling waves with particular attention given to attenuation and distortion. In the investigation described by Dowell, oscillograms were taken at the point of impulse-generator connection only. These tests were made with an oscillograph having a comparatively slow sweep, the principal object being to determine the effects of reflections.

To obtain the high-voltage surges, a lightning impulse generator designed especially for this class of investigations was used. Both this apparatus and the cathode-ray oscillograph have been described in detail in previously published articles.

Brune and Eaton report upon the results of a test of the first type mentioned which was made jointly by the General Electric Company and the Consumers Power Company (Mich.) on the Croton Dam-Grand Rapids 75-kv. line of the latter company. Line data and other features of these experiments are given in Table II. Because previous sphere-gap tests showed that the rate of attenuation is affected by voltage, polarity, and distribution of the charge over one or more conductors, test wave shapes were chosen to accentuate these features.

FACTORS AFFECTING WAVE PROPAGATION

A group of typical cathode-ray oscillograms replotted to uniform time and voltage scales is shown in Fig. 8. It may be noted that attenuation is much more rapid above corona voltage than below it (the calculated critical corona voltages for this line being 85 and 125 kv. for surges on one and on three parallel conductors, respectively).

These waves support the theory that in the mechanism of corona, as previously outlined, (1) the area surrounding a conductor becomes conducting only within an envelope of limited radius; (2) when the voltage rises above the corona voltage, charges enter the envelope and remain there until the conductor voltage falls, returning then to the conductor and thus holding up and flattening out the tail of the wave. The process can be likened to the discharge of one condenser into another through a resistance, the difference being that on a transmission line the quantities are distributed rather than lumped, and are variable depending upon the voltage.

It may be noted, however, that other factors besides corona appear to affect the propagation of the surges. This is brought out clearly in those oscillograms where the crest voltage is below the critical corona value. Such waves exhibit changes in form which might be caused by line resistance, the general effect observed being a continuous attenuation of the front of the wave, a reduction in crest voltage, and lengthening of the wave tail. This is accounted for by the variable character of the line resistance due to skin effect as explained in another article of this group.

Lewis and Foust attribute the flattening of the wave front and lengthening of the tail to the lower velocity of propagation for the high-voltage portion of the wave, but that such a point of view must not be accepted finally as an explanation of the mechanism of surge propagation without a closer examination than has yet been given. These authors state further that the influences of corona and polarity upon surge propagation have been shown to be great and that both probably are determining factors. Conditions of relative energy loss on the front, crest, and tail of the wave, however, are said to be but little understood, the shift of energy relations within the wave possibly accounting for wave changes which have been demonstrated.

ATTENUATION

Attenuation curves for several tests showing maximum voltage against miles of wave travel are shown in Fig. 9 (Brune and Eaton). The effect of polarity upon attenuation is evident in these curves at once, the positive surges being attenuated more rapidly than the negative surges, especially by corona. In comparing waves *I* and *J* with waves *A* and *B*, it may be noted also that short waves are attenuated more rapidly than are long waves.

To draw a comparison in attenuation between waves on one and on three parallel conductors, respectively, reference is made to curves *C* and *I* (which have approximately the same length at a voltage of about 600 kv.). It may be seen readily that surge *C* attenuates more slowly than surge *I*; the same comparison may be drawn between surges *D* and *J*. It seems obvious, therefore, that a surge on three conductors will attenuate more slowly than a corresponding surge on one conductor. This is in accord with the fact that where the same voltage is applied to three parallel conductors the voltage gradient will be less than around a single conductor. Therefore, the effect of corona (which is considered the greatest single contributing factor) will be less for three conductors than for one.

REFLECTIONS

The experiments described by Dowell were made on the 132-kv. Philo-Canton line of the Ohio Power Company (see Table II). The oscillograph in this case was coupled to the line at the point of connection of the lightning impulse generator. The voltage measured is the sum of the incident and reflected waves, the two components being entirely different in magnitude and shape. Crest voltages of the applied waves were obtained by sphere-gap measurements, and the voltages of successive reflections by comparative deflections on the oscillograms. All waves in these tests were applied to a single line either grounded or open-circuited at the far end. According to Dowell, if the applied wave is of the order of two or more times the length of the transmission line, successive reflections are superposed on one another and the individual waves must be segregated before attenuation constants can be obtained. This segregation was facilitated by use of the lattice diagrams described by Bewley in another part of this symposium.

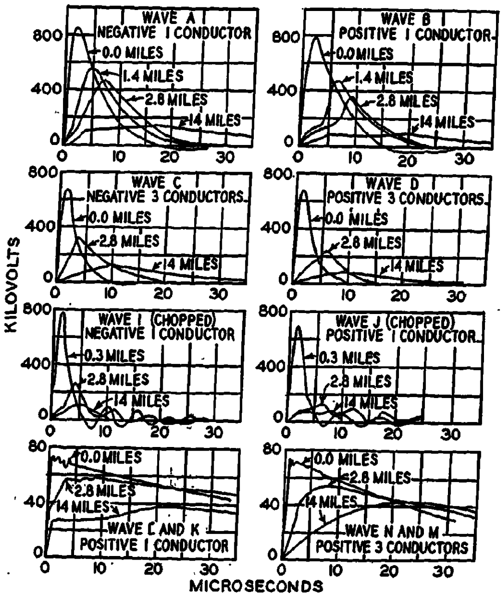


Fig. 8. Typical oscillograms replotted to uniform scales to illustrate change in wave shape with travel along the line

Reflection and refraction operators were derived mathematically for the existing line and terminal conditions. When applied to the function of time representing an incident wave, these operators give respectively the differential equations, the solutions of which are the reflected and refracted waves. This mathematical work was facilitated by the use of Heaviside's operational calculus. Attenuation constants were determined by comparing the calculated values with the oscillogram measurements. This method of attack seems especially applicable to cases wherein the wave of the applied impulse is long enough to permit a reflection to return to the point of measurement before the original wave has completely passed that point.

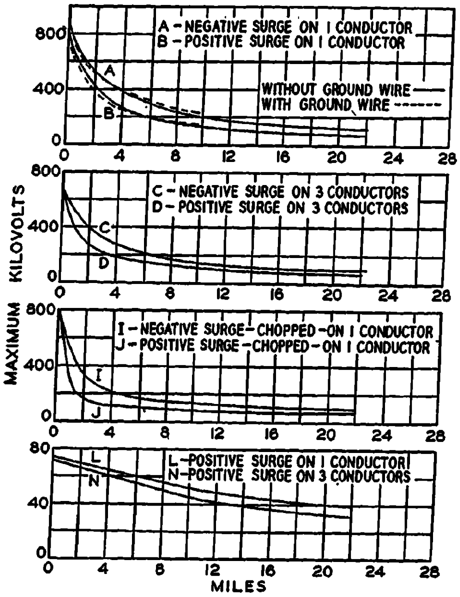


Fig. 9. Reduction in crest voltage of typical traveling waves

A typical lattice diagram for a typical line condition with an oscillogram taken at the lightning generator under the same condition may be seen in Fig. 10. The various crests in the oscillogram show definitely the effects of successive reflections especially at the fifth wave crest where reflections from both ends of the line are superposed.

Discussing attenuation on the basis of his results, Dowell agrees that the principal causes of wave attenuation and distortion are corona and, to a lesser extent, skin effect. However, he states that artificial lightning waves may attenuate considerably without an appreciable change in shape, other than some slowing down of the crest. From these findings it is thought permissible to treat such traveling waves as though the line were distortionless, in which case the attenuation is accounted for by a simple exponential decrement factor. Waves calculated under these conditions check quite closely with oscillogram measurements as may be seen from Fig. 11.

Dowell states further that while the segregation of

Typical comparisons between calculated waves and actual measurements

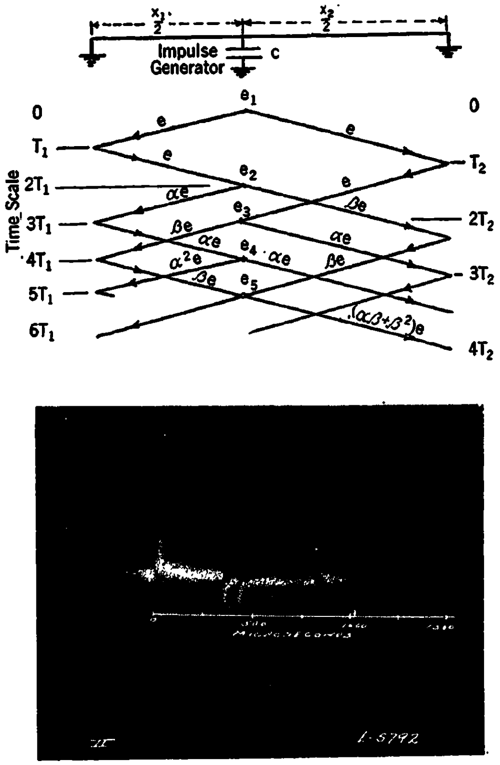


Fig. 10. (Left) Lattice diagram with oscillogram taken at point C for line condition shown. Note peak at fifth wave crest where two reflections are superposed (e_5 in diagram)

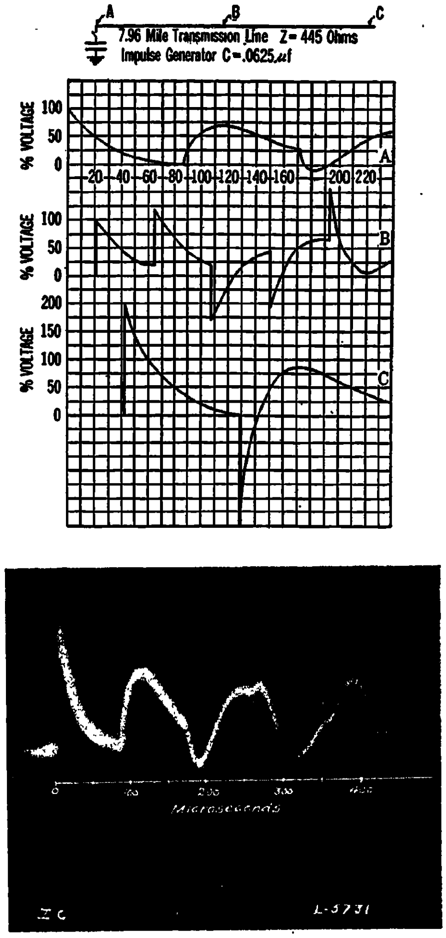


Fig. 11. (Right) Voltage-time relations for traveling wave on line open at one end; (above) computed curves; (below) oscillogram at point A

the attenuation from successive reflections is a long and laborious process subject to errors both in the mathematical and oscillographic work, the calculations demonstrate once more that traveling waves on transmission lines may be computed with excellent engineering accuracy by treating the line as distortionless.

INDUCED VOLTAGES IN PARALLEL CONDUCTORS

The theory of induced surges in parallel conductors developed by K. W. Wagner for the non-dissipative line, leads to a set of simultaneous linear equations expressing surge voltage on any conductor in terms of the surge currents on all the conductors. The usual convention of regarding all voltages as being composed of two traveling waves proceeding in opposite directions is observed. Because of the linear relationships in these equations an induced surge will have exactly the same wave shape as the inducing surge. An isolated conductor will have a potential due to its position in the field, but no current along the conductor.

Sphere-gap measurements of induced voltages made in 1929, however, showed that the ratio of induced to inducing voltages increased as the surge proceeded along the line. Since attenuation was also in evidence it followed that the theory of the non-dissipative line would not hold accurately.

Further light is thrown upon this phenomenon by oscillograms obtained by Brune and Eaton, a selection of which appears in replotted form in Fig. 12. In these oscillograms it may be seen that the wave shapes of induced and inducing surges differ widely. For both positive and negative waves the voltage of induced surge is lower at the beginning and higher later on than that which would be due to the field of the inducing surge alone, while the negative induced surge is actually of opposite polarity at the beginning. This peculiarity in the induced wave cannot be attributed to corona

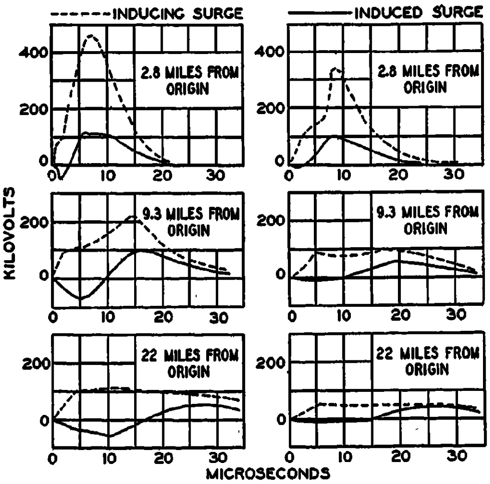


Fig. 12. Replot of induced and inducing surges in free conductor for both negative (left) and positive (right) inducing impulses

effects; the same conditions have been found to exist on surges below the critical corona voltage.

In an attempt to arrive at some conclusion in regard to this effect, Brune and Eaton say that there appears to be a continuous separation of charge taking place within the induced surge. A charge having polarity opposite to that of the main surge is thought to collect in front of the induced surge, thus decreasing the resultant voltage there, while charge of the same polarity increases the voltage in like manner in the latter portion of the induced surge. The mechanism by which this separation takes place is not at all clearly understood, but it seems to be connected in some way with the process of attenuation and distortion of the main wave. Thus it appears that not only is the self-surge impedance no longer a constant for wave propagation on a dissipative line, but also that the mutual surge impedances have become more complicated. This theory would account for the flattening in wave crest noted in Fig. 8, waves *C*, *D*, and *N*.

Field Tests With Natural Lightning

Although lightning surges of as high as 5,000 kv. have been recorded, only about ten per cent of these have crest voltages of more than seven times normal line voltage. One important result of recent investigations is the proof that a direct stroke can occur to a tower or ground wire without causing a flashover.

NATURAL LIGHTNING INVESTIGATIONS, as may be implied, differ from the experiments just related mainly in that the tests and measurements were confined to natural lightning discharges occurring during storm periods, and the resulting line surges. Accordingly the results have been correlated with line flashovers, faults, and general system performance. A few measurements were obtained at points very close to actual direct strokes. The effects of special ground wire construction, tower grounding cables, counterpoises, and various other protective measures were investigated.

Inasmuch as these investigations were conducted for the most part with the lines in operation an opportunity was afforded for evaluating the results in terms of actual operating experience.

TEST EQUIPMENT AND INSTRUMENTS USED

Besides the cathode-ray oscillograph which has found universal application in all lightning surge studies, the klydonograph also has been used to a large extent for making both voltage and current measurements. Surge-voltage recorders, also well known in this class of work, have been used in many cases. The field intensity recorder described in previously published articles also has found some application. Three new devices, developed especially for this sort of investigation and used in some of the more recent tests, are:

1. Direct-stroke recorder.

This instrument consists essentially of a small klydonograph with timing accessories omitted, and is built into an ordinary telephone receiver It usually is coupled directly to the transmission-line tower through a resistance potentiometer. (See Fig. 13)

2. Surge or flashover indicator.

This is a small device which can be applied to each insulator assembly on a tower and is so designed that an indication visible to a ground patrolman will show after a flashover on that assembly has occurred.

3. Storm-severity meter.

This consists essentially of a roll-film box camera containing a special glow tube, the tube being connected between a 30-ft. vertical antenna and ground. Collapse of electric charges collecting on the antenna during storms causes the tube to glow and record a spot on the film; thus the intensity or degree of darkness of this spot is an indicated function of the number of charges on the antenna and their magnitude.

The lines on which these investigations have been carried out are indicated in Table II (see also Fig. 15). Line construction data are given with special features noted; instruments used in each case are listed to give some indication of the scope of each investigation. Unusual features of each investigation are noted also.

The results although sometimes difficult to interpret nevertheless reveal many interesting aspects of the lightning situation and the line protection problem. Wherever possible attempts have been made to correlate system disturbances directly with either direct strokes or induced surges. The inconsistencies which still exist are due partly to an incomplete understanding of the fundamental nature and behavior of lightning, and partly to the widely varying nature of the lightning discharge itself.

DIRECT AND INDUCED STROKES

That effective measures for protection may be adopted, it is necessary first to distinguish between direct and induced strokes, the relative magnitudes of their potentials, and the frequency of occurrence and other characteristics, and then to evaluate these in the light of system performance. That direct strokes to line conductors nearly always cause flashovers and trip-outs, is quite generally agreed; and that direct strokes to ground wires or towers often do also. In-

TABLE II—Line and Instrument Data with Special Features of Field Investigations

Line Data									
Name and location	Operated by	Operating kv.	Miles of line under test	Structures	No. circuits	Configuration	Other features	Instruments used	Special features of investigations
Croton Dam-Grand Rapids (Michigan)	Consumers Pwr. Co.	70	45	Steel tower	1	Vert.	1. One ground wire throughout	1. 1,500,000-volt impulse generator 2. Cathode-ray oscillographs	1. Characteristics of surges induced in parallel conductors investigated. 2. Effects of tower counterpoises studied.
Philo-Canton (central Ohio)	*Ohio Pwr. Co.	132	73	Steel tower	2	Vert.	1. One overhead ground wire throughout 2. Two lightning arresters installed on line	1. Surge voltage recorders 2. Cathode-ray oscillographs 3. Direct stroke recorders 4. Flashover indicators 5. 1,000,000-volt impulse generator	1. Two investigations made: (1) attenuation and reflection experiments with artificial lightning surges; (2) a study of natural lightning disturbances. 2. Surge voltage recorders installed on two 132-kv. lightning arresters. 3. "Double-sweep" cathode-ray oscillograph used (see Fig. 14).
Roseland-Siegfried & Roseland - Plymouth (central and southern N. J.)	Pub. Serv. Elec. & Gas Co.	220	6	Steel tower	1	Horiz.	1. Two ground wires throughout 2. Arcing rings on all insulator strings	1. Portable 1,000,000-volt "lightning" generator 2. Cathode-ray oscillographs 3. Klydonographs	1. Tests made while lines were under construction. 2. Flashovers related to ground wire protection and tower footing resistance. 3. Lightning currents measured by klydonographs installed directly in parallel with power footings.
Wallenpaupack-Siegfried (eastern Pa.)	Penn Pwr. & Lt. Co.	220	65	Steel tower	1	Horiz.	1. About 37% of line equipped with two overhead ground wires 2. Counterpoises on 2.5-mi. section 3. 80 towers fitted with grounding cables 4. 3.5-mi. section with overhead diverting cables	1. Cathode-ray oscillographs 2. Flashover indicators 3. Surge voltage recorders 4. Direct stroke recorders 5. Magnetic oscillographs and high-speed recorders 6. Field-intensity recorders 7. Rate-of-change-of-field recorders 8. Storm severity meters	1. Fast- and slow-sweep cathode-ray oscillographs used. 2. Antennas installed for measuring induced voltages. 3. Two lightning arrester installations 4. Effects of direct-stroke diverters and special tower grounding investigated.
Deepwater - Pleasantvill (southern N. J.)	*Atlantic City Elec. Co.	132	30	Steel tower	2	Vert.	1. Two ground wires in vertical plane through center of tower over entire length of line 2. Arcing rings at both ends of insulator strings	1. Direct-stroke recorders 2. Surge-voltage recorders 3. Flashover indicators	1. Study of induced and direct strokes made with particular attention to resulting flashovers and outages. 2. Line designed for 132 kv., but operated at 66 kv. during entire test period.
Turner-Logan, Glen Lynn-Roanoke, & Turner-Cabin Creek (western parts of Va. & W. Va.)	*Appalachian Elec. Pwr. Co.	132	59	Steel tower	2	Vert.	1. One ground wire throughout 2. Conductors on two sides of towers in reverse-phase order 3. Grading shields and horns on all insulator strings 4. Tower footing resistances high	1. Klydonographs 2. Cathode-ray oscillographs 3. Direct stroke recorders	1. Four-year study of natural lightning disturbances. 2. Data were obtained on one line both before and after the installation of a ground wire. 3. Klydonographs installed on lightning arresters at substations. 4. Line flashovers correlated with tower elevation.
Camden-Magnolia (southern Arkansas)	Ark. Pwr. & Lt. Co.	110	28	Wood pole	1	Horiz.	1. Fused horn-gaps from each phase to ground at 1-mi. intervals except in 9-mi. section near oscillograph station	1. Cathode-ray oscillographs 2. Klydonographs	1. Behavior of lightning surges on a highly insulated wood pole line observed. 2. A new arrester of the air-expulsion type tried out.

*Subsidiaries of American Gas & El. Co.

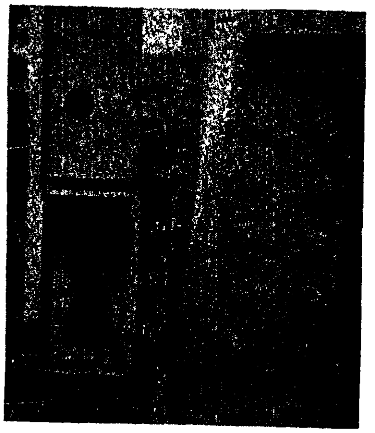


Fig. 13. Direct-stroke recorder installed at base of tower

duced surges, either from cloud discharges unaccompanied by stroke to earth, or from direct strokes to nearby objects, may in some cases be sufficiently high to cause flashovers and line trip-outs. The probability of induced voltages causing line outages is greatly reduced by overhead ground wires, and also depends to a large extent upon tower footing resistance and line insulation.

Bell and Price, in reporting the results of extensive investigations pursued on the 220-kv. transmission system of the Pennsylvania Power & Light Company, state that direct strokes usually contact only one object (ground wire, power conductor, or tower top) and do not fork to other objects (power conductors for instance) in the same vicinity. They also state that voltages induced in the conductors by the collapse of cloud fields do not appear to endanger service over circuits as highly insulated as the lines in question. In their investigation an attempt was made to determine the approximate magnitude of induced surges by measuring the voltage induced in a 100-ft. antenna installed near the line, but not coupled to it. A potential of from 2,700 to 3,150 kv. was measured on this antenna, but the corresponding voltage induced in the line conductor was only about 350 kv. In no case could extremely high voltages measured on the transmission line be correlated with those measured on the antenna.

During this same investigation an oscillogram was obtained of a direct stroke of negative polarity which occurred not more than 500 ft. from the lightning laboratory and which caused a trip-out and single-phase fault. This oscillogram is shown in Fig. 16. As may be noted, the voltage rise was rather gradual for the first 3.5 microsec., but was quite rapid during the next 2 microsec., until the insulator flashed over on the crest of the wave at a potential of more than 2,760-kv., the maximum range of the oscillograph.

Another interesting record of a direct stroke is that obtained by Gross and Cox. (Fig. 17.) This represents a klydonograph record, simultaneous records being obtained by both the direct-stroke recorders and cathode-ray oscillograph. The line (Turner-Logan) tripped out three times within 20 minutes during this storm, but the only flashover which could be located by inspection after the storm, was on the top phase of the tower adjacent to that at which the klydonogram was obtained.

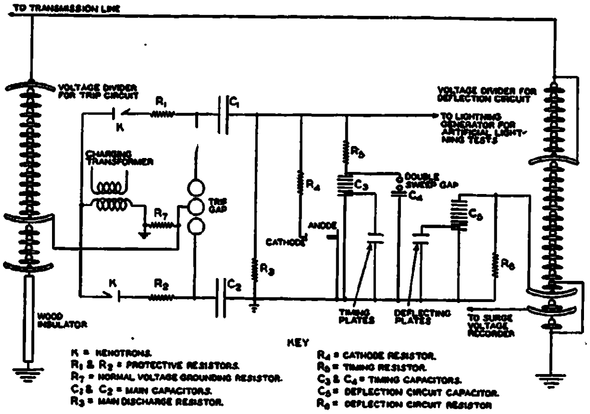

TO TRANSMISSION LINE
VOLTAGE DIVIDER FOR TRIP CIRCUIT
R₁
C₁
K
CHARGING TRANSFORMER
TRIP GAP
R₇
K
R₂
C₂
R₃
R₄
CATHODE
ANODE
R₅
C₃
DOUBLE SWEEP GAP
C₄
C₅
R₆
VOLTAGE DIVIDER FOR DEFLECTION CIRCUIT
TO LIGHTNING GENERATOR FOR ARTIFICIAL LIGHTNING TESTS
WOOD INSULATOR
TIMING PLATES
DEFLECTING PLATES
TO SURGE VOLTAGE RECORDER
KEY
K = KENOTRONS.
R₁ & R₂ = PROTECTIVE RESISTORS.
R₇ = NORMAL VOLTAGE GROUNDING RESISTOR.
C₁ & C₂ = MAIN CAPACITORS.
R₃ = MAIN DISCHARGE RESISTOR.
R₄ = CATHODE RESISTOR.
R₅ = TIMING RESISTOR.
C₃ & C₄ = TIMING CAPACITORS.
C₅ = DEFLECTION CIRCUIT CAPACITOR.
R₆ = DEFLECTION CIRCUIT RESISTOR

Fig. 14. Circuit diagram for a "double-sweep" cathode-ray oscillograph

Two cases are reported by Sporn and Lloyd wherein trees were struck at points quite near the line. In one case two trees respectively 500 and 1,500 ft. from the line were struck. The nearest surge-voltage recorder (more than a mile away) indicated two highly damped surges of −4.8 and +2.4 times normal voltage, but it was impossible to correlate either stroke with a line trip-out or even a flashover. By a peculiar coincidence another tree at this same point had been struck previously. This tree was 360 ft. from the line and near the 500-ft. tree mentioned in the other case. At that time the surge recorder (located at an adjacent tower) indicated a positive maximum voltage of 2,100 kv. A trip-out occurred apparently caused by the high voltage induced from the direct stroke to the tree. These two cases well illustrate some of the inconsistencies encountered.

Lewis and Foust comment on the question of direct and induced strokes as follows:

"Apparently there is evidence to the effect that direct strokes play an important part in transmission flashovers and outages. There is a great deal of evidence that induced strokes also are highly important. There is insufficient evidence at the present time to evaluate more exactly these two types of strokes."

CREST VALUES OF LIGHTNING SURGES

As might be expected the crest values of lightning voltages and currents are subject to many variations also. Bell and Price report a maximum voltage well above 3,000 kv. (see Fig. 16) measured at a point not more than 500 ft. from the stroke. Currents from less than 40,000 to about 260,000 amperes are indicated in their report.

Voltage measurements from a 4-year study are plotted by Gross and Cox as shown in Fig. 18. Voltages of surges due to switching also are shown in this diagram. The maximum lightning voltage recorded was about 26 times normal, or 2,800 kv. It may be noted that only 10 per cent of the surges were of more than seven times normal line voltage. It has been computed also that the lines involved in this investigation (Appalachian Electric Power Company) are subject to 4.6 lightning voltages of 15 times normal per 100 mi. of line per year. Compared to other published data this would show that the lines in this territory are subjected to lightning disturbances of greater than average severity.

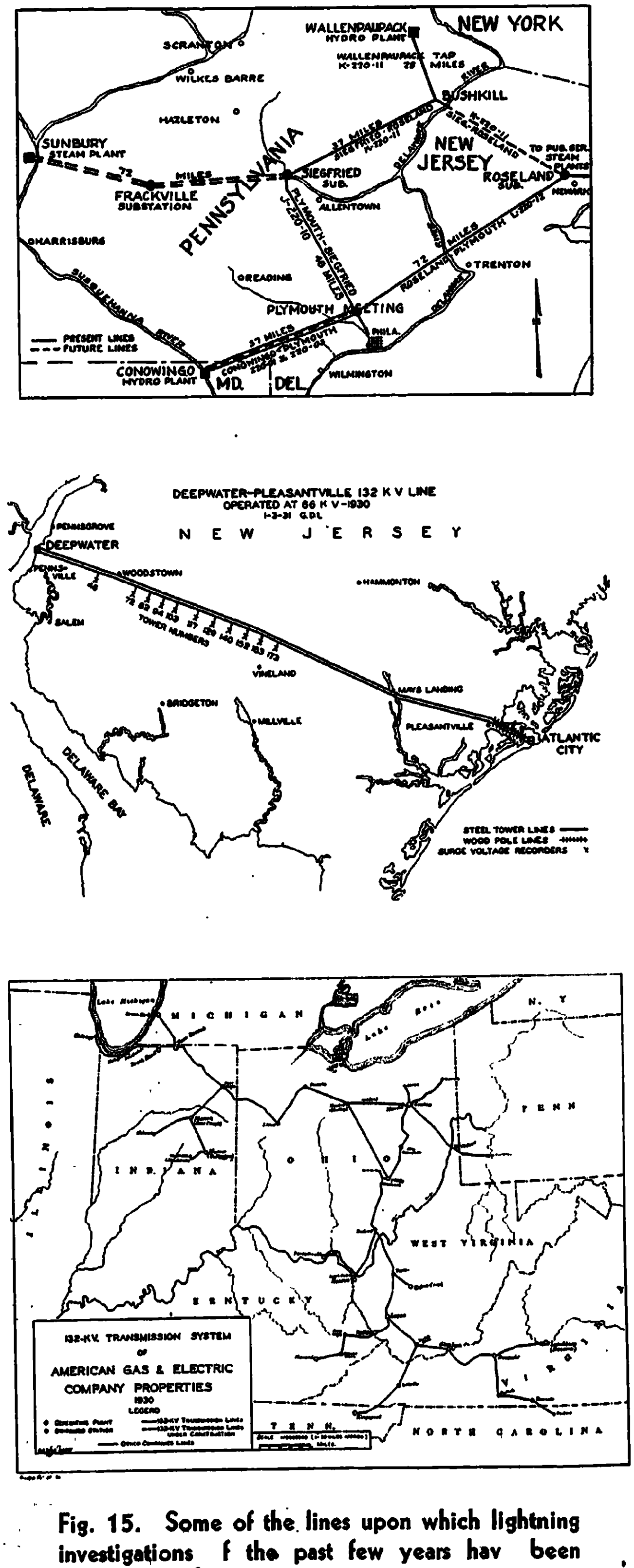


Fig. 15. Some of the lines upon which lightning investigations of the past few years have been concentrated

In the same investigation similar results were obtained for lightning voltages appearing at substations. In this case the highest lightning voltage recorded was only twelve times normal while only 4.5 per cent were more than seven times normal. This reduction is attributed to the lightning arrester protection installed at substations and also to the number of paths into which an incoming surge can be dissipated.

Sporn and Lloyd report a maximum lightning voltage obtained (Philo-Canton line—1930) by surge recorders of only 6.5 times normal (700 kv.). The low severity of lightning storms during that year in that section of the country is believed to be the reason for the absence of higher voltage measurements. Discharge currents of from 40,000 to 670,000 amperes were indicated, however, (by adding the tower currents), the current distribution for a typical case being shown in Fig. 19. These values are subject to a certain amount of error because of the fact that all currents may not have been recorded simultaneously. Reflections at points of changing surge impedance also would affect the measurements.

Lewis and Foust have plotted (see Fig. 20) the results of lightning voltage as measured by surge-voltage recorders based on a study of 678 lightning surges occurring on fourteen systems during the years 1926-1930 inclusive. Voltages due to switching are shown also, based upon 724 surges occurring during the years 1927-1930 inclusive on practically the same systems from which the lightning data were taken. These curves are in close agreement with those obtained by Gross and Cox.

All of the results mentioned so far have been concerned with lines having steel supporting structures.

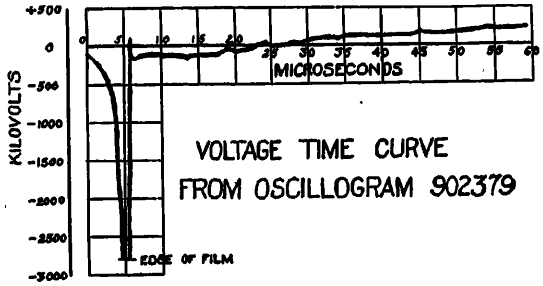


Fig. 16. Oscillogram of a direct stroke taken about 500 ft. from point of stroke and 125 ft. from insulator flashover; flashover occurred also at an adjacent tower and was followed by a line trip-out

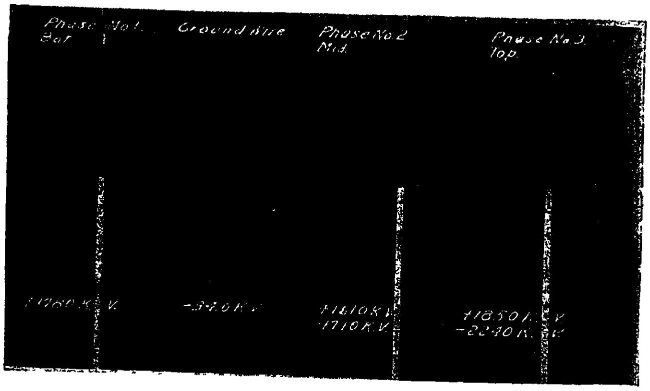


Fig. 17. Klydonograph record of a lightning surge

Negative surges are indicated on ground wire and two top conductors; positive surges are in evidence on all line conductors. A simultaneous cathode-ray oscillogram showed the disturbance to b oscillatory. (Important details of klydonograph records are unavoidably lost in reproduction.)

Much higher voltages due to lightning have been reported by Pittman and Torok in their tests on the Camden-Magnolia (Ark.) 110-kv. wood-pole line. On this line pole-grounding wires are installed only on guyed structures which normally are about one mile apart. The maximum voltage recorded in the investigation was approximately 5,000 kv. measured at a point about 4 mi. from the point of stroke (see Fig. 21). The indicated rate of potential rise is about 4,000 kv. per microsec. These values contrast sharply with the maximum reported on steel-tower lines. It appears quite obvious that the voltage of the discharge if measured at the point of incidence would have been much higher than the voltage measured 4 mi. distant, although the actual maximum value is a matter of interesting speculation.

An examination of the surroundings near the point of discharge of this bolt showed that an arc had been established from a line conductor to a telephone wire crossing 22 ft. below the line. In addition both 50-ft. poles on the H-frame supporting structure adjacent to the telephone line crossing were splintered. Allowing 350 kv. per ft. as the breakdown strength of air, a potential of 7,500 kv. would be required to flash from conductor to telephone line. However, since corona loss at such high voltages is tremendously high, it is quite obvious that a 2,500-kv. difference is not sufficient to account for the voltage lost in 4 mi. of travel. These facts would tend to place the voltage of the original stroke at a value somewhat higher than 7,500 kv.

FLASHOVERS AND TRIP-OUTS

Of the 65 line insulator assemblies flashed on the 220-kv. Wallenpaupack-Siegfried line, Bell and Price report that 71 per cent showed glaze burns characteristic of dynamic arcs. Of 38 flashover indicator operations, 29 (76 per cent) were associated with marked insulator assemblies. Most of these flashovers occurred on phase conductors occupying the outer positions on the towers. Some 24 trip-outs were associated with the 65 flashovers most of these being accompanied by single-phase faults. Their results show in addition that 32 flashovers out of 36 involved only one phase, but that in 15 of these 32 more than one insulator assembly was flashed over.

Gross and Cox state that of the surges higher than 600 kv. recorded in their investigation, thirteen were associated with line trip-outs while ten were not. They account for the existence of high-voltage surges (higher than the 60-cycle line flashover voltage) without flashover and trip-out by the fact that when a direct hit to a tower occurs the tower potential is altered with respect to ground because of its surge impedance and footing resistance; although the voltage to ground may be higher than the line flashover value the voltage between line and tower may be somewhat less. This explanation, however, does not account for the absence of trip-outs in all cases, and it is believed consequently that lightning flashovers sometimes may occur without subsequent power arc and line outage.

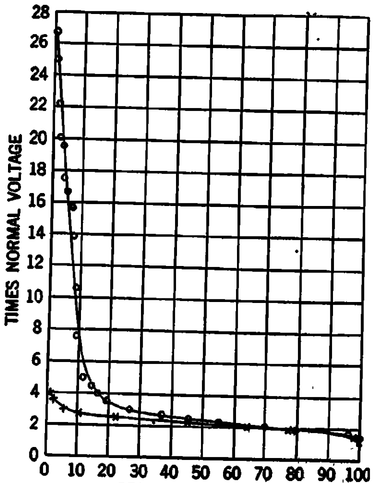


Fig. 18. Surge voltages reported by Gross and Cox for the period 1927-30 inclusive (based upon 143 lightning and 98 switching surges)

In attempting to correlate these trip-outs with tower footing resistance and line elevation, these authors definitely state that, "an attempt to relate line flashovers to tower footing resistance proved futile." As regards tower elevation, there was some tendency for flashovers to concentrate near high points in the line contour, which experience is in accord with the reasonable expectation that lightning will strike the most exposed points; these, of course, being the points of highest elevation.

In the results obtained by Sporn and Lloyd during 1930 on the Deepwater-Pleasantville 132-kv. line, twelve direct strokes were recorded, only three of which could have resulted possibly in a trip-out, while on the 30-mi. section of the Philo-Canton line thirteen direct strokes were recorded, only one of which possibly could have produced a trip-out. Of a total of 107 surges recorded in Ohio only 33 per cent were due to lightning, 60 per cent being due to switching. Notwithstanding the many surges recorded, only four trip-outs occurred, three of which involved both circuits. There were indications, however, that flashovers had occurred in some cases where trip-outs had not.

Pittman and Torok state that on the wood pole line upon which their investigations were made, voltages as high as 2,000 kv. were recorded without any switch operation. This was not thought particularly surprising since the line was equipped with several drain points set to operate at about that voltage. General experiences on this line have pointed to the conclusions that voltages of a harmful character occur only when direct strokes or their branches terminate on the conductors, and that trip-outs on ungrounded wood pole construction usually result from phase-to-phase flashovers.

Lewis and Foust outline three conditions under which line insulation may flash over as a result of direct strokes. They are (1) a stroke to line conductor, (2) a stroke to the tower, and (3) a stroke to the ground wire between towers where the potential is such that flashover will occur between ground wire and line conductor. Direct strokes to line conductors appear to be of rare occurrence where steel towers and overhead ground wires are used. Where insulator flashover does occur under these conditions, it apparently results through high tower potentials caused by high footing resistance.

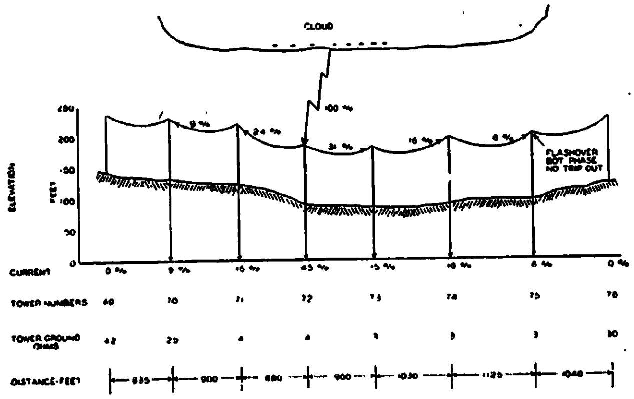


Fig. 19. Typical lightning current distribution on either side of a struck tower

It is further stated that where flashover does occur from tower to conductor the spread to other insulator assemblies on the same tower may be prevented by the resulting reduced impedance between tower and ground. Experience has shown also that a flashover is not necessarily followed by a line trip-out. A permanent arc is not set up because the power voltage to ground and conductor current do not have sufficient amplitude and proper polarity relations to establish it.

Extent of System Affected

The extent to which a transmission system may be affected by lightning discharges appears to depend mainly upon line design and insulation; also upon whether or not flashover occurs at or near the point of incidence. On steel-tower lines where flashover occurs, experience has shown that the disturbance is limited to five or six adjacent towers, flashover in most cases occurring on one phase only, but in many cases on two insulator assemblies at adjacent towers.

Fortescue and Conwell state that if a tower or ground wire is struck and no flashover results, severe electrical disturbance is limited to a few structures, and any surge propagated over a conductor will be of extremely low magnitude. They also agree that disturbances on tower and ground-wire systems usually are limited to approximately six spans, where tower footing resistances are low. Potentials induced on the conductor arising from such surges on the ground wires become nil beyond the region of the disturbance. Thus no surge on the conductor can be propagated beyond this region unless flashover takes place.

In addition to the foregoing, Fortescue and Conwell discuss in some detail the effect of line construction on surges propagated over the lines to substations. It is finally concluded that ordinarily with only one type of construction, namely, ungrounded wood pole, will the potentials be sufficiently high to endanger substation equipment. Pittman and Torok's results agree with the fourth case just described in that voltages of high magnitude may be transmitted for several miles along highly insulated transmission lines and thus appear at terminal apparatus. This is true especially when direct strokes or their branches terminate on line conductors.

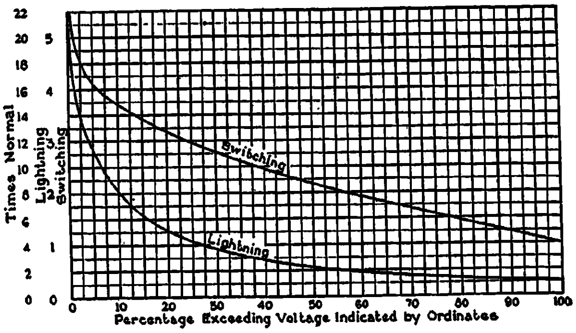


Fig. 20. Surge voltage curves compiled by Lewis and Foust based upon data from fourteen systems for the years 1926-30 inclusive

GROUND WIRES AND TOWER FOOTING RESISTANCE

"That a direct stroke could occur to the line without producing a trip-out" is said by Sporn and Lloyd to be one of the outstanding determinations of the 1930 lightning investigation and is believed to be due to the protection offered by the overhead ground wire in diverting the stroke to ground. In regard to tower footing resistance they continue that "the better showing in Ohio was probably due to the lower average tower ground resistance in Ohio, mostly less than 10 ohms against one-third of more than 50 ohms in New Jersey."

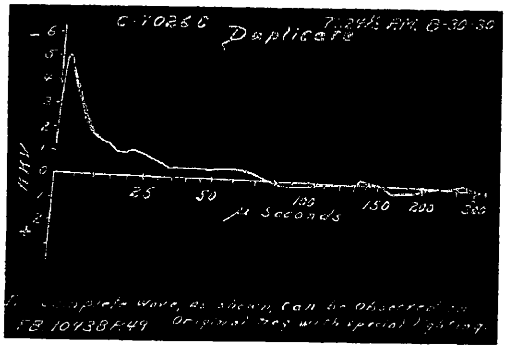


Fig. 21. 5,000-kv. surge measured 4 miles from point of stroke

All three phases flashed to ground splitting the wood-pole supporting structure and causing a circuit breaker operation. Also center conductor flashed 22 ft. to a telephone line at a crossing 3,600 ft. from the stroke

Data obtained in these field investigations have established without question the effectiveness of the conventional ground wire for protecting lines against lightning disturbances. In general it has been found that only in rare cases will a line conductor be struck when steel tower construction with conventional ground wires are used. The results show in addition that from two to three times as many interruptions occur due to lightning on lines without ground wires as occur on lines with ground wires installed.

It is reported by Lewis and Foust that out of 231 total interruptions on the transmission system of the Public Service Electric & Gas Company (New Jersey), only six have occurred on 66- and 132-kv. lines where overhead ground wires are installed. Mention is made also of a 14-mi. 66-kv. double-circuit steel-tower line operated by the Philadelphia Electric Company which is equipped with two ground wires, one placed vertically over each of the outermost conductors. This line has not experienced an outage due to lightning in fourteen years. The beneficial effect of low tower footing resistance also is well emphasized in this case since the resistances are all unusually low and uniform, being of the order of 4 ohms each. In this connection Fortescue and Conwell, speaking of the 220-kv. lines of the Public Service Electric & Gas Company, state that "during one year's investigation on lines equipped with ground wires, no flashovers have occurred where tower footing resistances are less than 5 ohms."

A direct comparison between lines with and without ground wires has been obtained by Bell and Price. This comparison is illustrated in Fig. 22, where the number of flashed insulators per tower per year has been plotted against tower footing resistance for each case. The effect of ground wires appears to be to reduce the number of flashovers to about 15 per cent of those which otherwise would occur. The effect of tower footing resistance at least above 17 ohms seems to be negligible in this case.

Some difference of opinon appears regarding the benefits of low tower footing resistance. It is quite generally agreed, however, that extremely low resistances (only a few ohms) do show a marked beneficial effect.

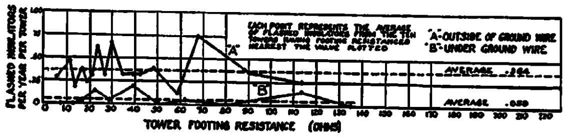


Fig. 22. Effects of tower footing resistance and overhead ground wires on insulator flashovers occurring on a 220-kv. line section

WAVE SHAPES

According to Lewis and Foust, oscillographic work on transmission lines under natural lightning conditions has shown that waves to be expected on transmission lines vary in time to crest from about 1 microsec. to several hundred, but that the tail of the wave extends over a much wider range. In general the lower voltage surges appear to be of longer time duration.

Wave shapes measured at or near the origin of surges have fronts which bring the conductor potential up to flashover values in the order of about 1 microsec. These high-amplitude waves of steep front usually cause flashovers and therefore are reduced quickly to low potential values. Apparently voltage waves rising to fairly high values, but still under insulator assembly flashover value, would possess a longer time to crest and also a wave tail of at least some 10 to 100 microsec. in length.

Wave fronts rising at the rate of from 1,000 to 2,500 kv. per microsec. have been measured in several cases, but Pittman and Torok in their test on a wood pole line found that surges at the point of origin may have a rate of rise of 4,000 kv. or more per microsec.

Sporn and Lloyd present curves showing approximate wave shapes for the maximum, minimum, and average wavelengths observed on 29 oscillograms recording 50 kv. on crest or higher, and therefore not causing flashovers (see Fig. 23). Wave shapes for higher voltage surges where flashover occurred are shown in other illustrations.

Bell and Price state that among other things the wave forms of lightning surges appear to be dependent upon whether the surge originated and created fault on the phase to which the oscillograph is connected, or on either or both of the other two phases.

Gross and Cox in speaking of attenuation agree that attenuation is greater for positive than for negative surges. They assert further that attenuation of high-voltage surges is very rapid, maximum crest values in the order of 2,000 kv. being reduced to one-half that value within about a mile. An empirical formula has been developed from actual measurements by which the voltage reduction or attenuation can be determined for any point on the line. This is illustrated in Fig. 24. This formula contains constants which depend upon the characteristics of the line under consideration, and agrees fairly well with results of attenuation studies where artificial lightning has been used.

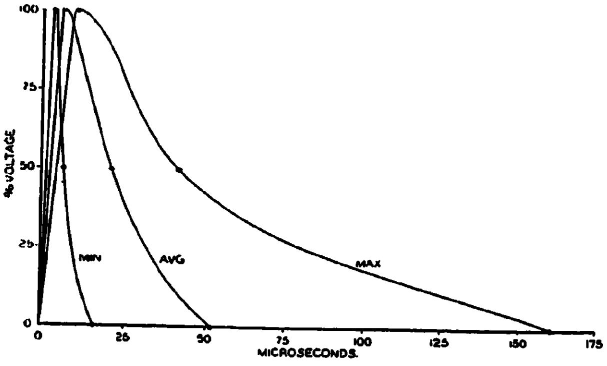


Fig. 23. Empirical wave shapes of lightning surges showing envelopes for maximum, minimum, and average time relations

Wave shape and attenuation studies of natural lightning discharges in general agree fairly well with the results of theoretical studies outlined previously, but in any case the wave shape of a particular surge appears to depend upon (1) whether the surge results from a direct stroke or is induced, (2) polarity, and (3) whether or not flashover takes place.

POLARITY

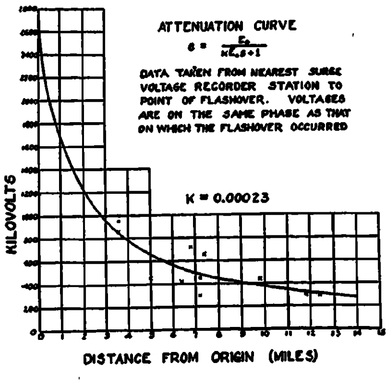
Some difference of opinion exists regarding the polarity of lightning discharges as evidenced by excerpts presented herewith. Bell and Price state that most lightning strokes are of negative polarity, as indicated by measured structure currents. Smaller proportions appear to be oscillatory with negative polarity predominating. Positive surge voltages between conductor and tower usually are indicated at locations where a ground wire or conductor not coupled to the surge voltage recorder is contacted by direct strokes. These therefore are not indications of induced surges due to cloud fields.

Gross and Cox report that 60 per cent of the conductor surges measured by them were negative, 40 per cent positive. Of the ground-wire surge voltages investigated, 70 per cent were positive, 21.5 per cent negative, 8.5 per cent oscillatory.

Sporn and Lloyd found that lightning surges were positive ten times as often as negative, but that each of the stroke recorder charts indicated the cloud to be negative. These authors advance the belief that overhead ground wires prevent the majority of negative lightning bolts from reaching phase wires and that, therefore, positive surges measured on the lines are due to induction.

Lewis and Foust state that measurements of cloud field potentials have established beyond question that fields of both polarities are present, and that field polarity at a point on the ground may change from positive to negative or from negative to positive during storm. Additional statements made by these authors, however, are to the effect that all lightning stroke recorder charts of direct strokes to tower indicate the tower to be negative. From this it is inferred that clouds are negative and the ground positive. With the tower structure positive with respect to the cloud, breakdown proceeds from structure to negative cloud, and the strokes terminate on the grounded structure under this polarity condition. Should the tower structure become negative with respect to clouds, strokes would proceed from the cloud, and the probability of the tower being struck would not be great. While this conception appears to reverse the accepted picture of cloud-to-ground strokes, nevertheless it is said to be consistent by being in accord with laboratory and field experience.

Fig. 24. Attenuation curve and formula determined empirically from surge-voltage recorder data



Protection Against Lightning Surges

Requirements for a "lightning proof" line, where this seems justified economically, are outlined in this article. Insulation alone is not the final answer, only one of several important features of proper line design. A new arrester of the gap type is described also, wherein the breakdown medium is a column of air.

INSULATION FAILURES arising from lightning discharges are shown by experience to be the cause of a majority of transmission line outages. It is highly desirable, therefore, that protective measures be adopted and practical protective devices be installed to reduce the number and seriousness of such disturbances. That it is impractical to over-insulate a line sufficiently to withstand lightning voltages is substantiated by records which show that sometimes even on wood pole lines there are impressed surge potentials of sufficient magnitude to flash over the wooden structures to ground.

OVERHEAD GROUND WIRES

The effectiveness of conventional overhead ground wires for lightning protection where steel tower construction is used has been well emphasized by the investigations covered in other articles of this group. For ground wires to be most effective, however, according to general consensus of opinion tower footing resistances should not exceed 4 or 5 ohms.

So-called diverting wires have been experimented with on operating lines. These are special ground wires which may or may not be insulated from tower structures, and which generally are located at a greater distance above the line conductors than are the conventional ground wires. One form of diverter-wire construction is shown in Fig. 25; Peek suggests the possible effectiveness of other forms. According to Lewis and Foust, where such wires are supported on the line towers the only advantage appears to be that due to the increased height of these wires whereas when insulated from the tower structure and provided with independent grounds of low resistance, they possess the distinct advantage of keeping lightning currents out of tower structures. Protection offered by conventional ground wires, however, is said to be such that only in cases of high tower footing resistances do diverting wires appear feasible.

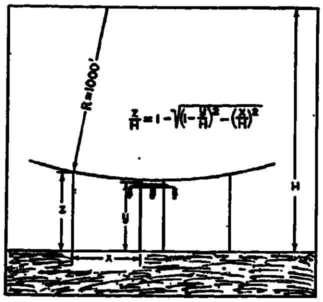

R=1000'
$\frac{Z}{H}=1-\sqrt{\left(1-\frac{Y}{H}\right)^2-\left(\frac{X}{H}\right)^2}$
Z
Y
H
X

Fig. 25. One type of diverter for lightning protection where high tower footing resistance cannot be avoided. Z represents the minimum height

TOWER GROUNDING AND COUNTERPOISES

Where tower footing resistance is too high for efficient ground-wire protection the resistance can be lowered materially by installing buried wires or cables connected directly to the tower legs. These wires may be either extended out radially from the tower or directly from tower to tower along the line. According to Peek radial wires of moderate length usually should be most effective; when installed in this way they are called counterpoises.

Investigations have been made recently to determine the effectiveness of counterpoise in reducing the surge impedance of a tower and thus increasing the effectiveness of the overhead ground wires. On this subject, tests made by Brune and Eaton using artificial lightning discharges revealed valuable information which will be outlined briefly in the following paragraphs.

Theoretically the counterpoise will tend to reduce tower footing voltages both by increasing the capacitance to ground (ground potential assumed to be at an appreciable depth below ground level) and by allowing leakage of charges from towers into the earth. On surge voltages, however, the time element enters in causing the counterpoise to behave like a line with a very high "leakance." Thus reflections may occur from the remote ends of the counterpoise cables and may make themselves felt at the tower footing ends.

For test purposes a tower location was selected where footing resistance measured at 50 cycles was rather high (400 ohms). Various arrangements of counterpoise were connected and surges discharged directly from the line into this grounding system. A probe was driven into the ground about 40 ft. away from the tower and the voltage was measured between that probe and the point at which the line was grounded. In some tests the line was grounded through a known resistance, the voltage across the resistance being taken as a measure of ground current.

Results of the first test are depicted in Fig. 26 where the curves show tower footing voltage for different lengths of counterpoise. As may be noted, extending the counterpoise in two directions produces practically double the effect of extending it in one direction only, but there is no great advantage apparent in extending it further than 1,000 ft. Since this distance in most cases would be more than a full span length the counterpoise in reality would involve at least two spans. How much shorter than 1,000 ft. the counterpoise may be made and still be effective will depend upon the length of surge to be expected and particularly upon the length of the wave front. Counterpoise can be made much more effective by extending in more than two directions, but right-of-way limitations in most cases would constitute a practical obstacle to this.

Additional tests show that current and voltage relations in a counterpoise are not proportional. This fact emphasizes again the non-constant nature of surge impedance. It has been found also that for long wave-fronts the effectiveness of a counterpoise is greater than for short ones. For a surge of approximately rectangular front such as might arise from a direct stroke to a tower, "leakance" of the counterpoise would have no effect initially; only its resistance functioning to limit the tower voltage. This is of considerable importance since with direct strokes the counterpoise to be effective must lower the tower footing impedance to such a value that the tower potential cannot rise to the flashover point.

INFLUENCE OF LINE DESIGN

The influence of line design constitutes another phase of the lightning situation which has been investigated to some extent. The importance of low surge impedance for the grounded supporting structure of a line has been duly emphasized and needs no further mention here. Certain other features, however, play an important part in determining how a certain line will react toward lightning disturbances.

First and foremost it is important that, if possible, line structures be kept clear of high elevations since lightning has a natural tendency to strike the highest object within its range. Where lines must be run over high ground, trees adjacent to the right-of-way will provide some protection. It is desirable also that span lengths be kept as short as possible so that reflections (which have a tendency to reduce the tail of the wave) will return to the point struck in the shortest possible time and thus tend to shorten the wave.

As previously brought out, where high tower footing resistance cannot be avoided, special overhead ground-wire construction or diverters may be employed. Where the economics of the situation will permit, these may be placed in such a way that they will shield the line from direct lightning strokes.

Peek has devoted a great deal of attention to proper line design as regards lightning protection. From the results of his studies he concludes that a "lightning-proof" line for almost any voltage seems feasible. The general requirements for such a line are (1) low elevation, (2) short spans, (3) low tower footing resistance, (4) ground wires, special ground-wire constructions or lightning diverters where tower footing resistances are high, and (5) highly insulated conductors (using from 14 to 16 disk insulator units as is customary on the present 220-kv. lines).

LIGHTNING ARRESTERS AND GAPS

The desirability of lightning arresters for protecting terminal equipment in substations is recognized generally. Lightning arresters also are finding some application on transmission lines, especially where provision for ground wires is not easily made. Arresters possess the distinct advantage of being easily placed at just the points where the protection is desired. Their most distinct disadvantage lies in the fact that

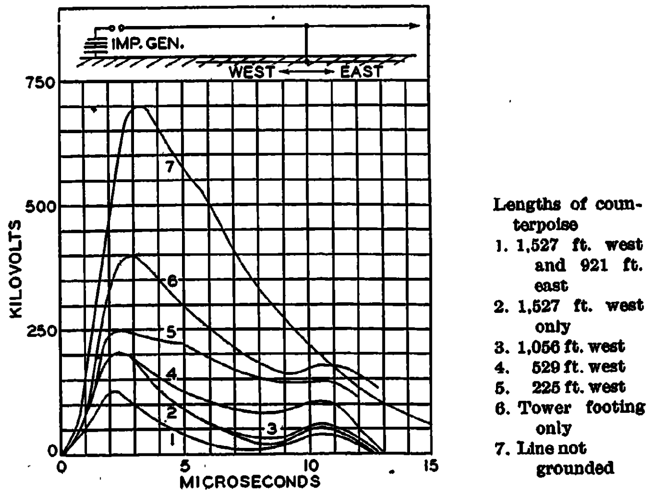


Fig. 26. Surge voltages at point of grounding for various lengths of counterpoise

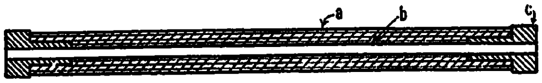


Fig. 27. Section of air-breakdown expulsion-type lightning arrester

(*a*) Fiber tube (*b*) Arc chamber (*c*) Metal electrode

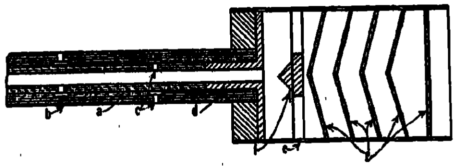


Fig. 28. Section of deionizing chamber for ends of expulsion arrester

(*a*) Inner fiber tube, (*b*) outer fiber tube, (*c*) gas vent, (*d*) electrode, (*e*) steel shell, (*f*) flame spreader, (*g*) perforated baffles their protective effect does not extend more than 500 ft. from the points of application. This feature may prevent arresters coming into general use on transmission lines.

In general, lightning arresters may be grouped into two classes: (1) those which have valve action, acting as good conductors when the voltage rises to a definite predetermined value and as insulators when the voltage drops below some lower value; and (2) those which become good conductors when the voltage reaches a definite value and continue to pass current until the zero point of the current cycle is reached. Familiar examples of the first class are the so-called Thyrite and oxide-film arresters. Familiar examples of the second type are gap devices, both fused and non-fused, of which there are several designs.

Devices of the latter type, consisting of fused horn-gaps, were in use on the 110-kv. wood pole line on which Pittman and Torok conducted their tests. These devices were expected to discharge current incident to lightning surges, and to interrupt subsequent 60-cycle power currents sufficiently promptly to prevent oil circuit breaker operation. In thirteen distinct operations, each resulting in blown fuses, a total of six flashovers occurred, none of which caused a switch operation. In one case, however, a three-phase short circuit resulted from a 5,000-kv. surge which arose from a direct stroke to the line. Details of this event appear elsewhere in this symposium (see Fig. 21). All three fuses in the nearest horn-gap device (about one-half mile away) were found blown, but this did not prevent a switch operation. These results support the previous statement that the protective effect of such a drain point does not extend very far beyond the point of application, even where lines are as highly insulated as this one. Moreover a single fuse seemed inadequate because many flashes of lightning are made up of several successive discharges following each other at very short time intervals, and because after a single fuse has blown no protection is afforded against additional strokes.

A multiple-fuse device accordingly was installed at six locations providing three fuses so arranged that they would blow successively upon the occurrence of lightning surges of sufficient magnitude to cause the gap to flash over. Results were fairly satisfactory, but the necessary continuous patroling and replacement made the arrangement unattractive economically.

AN INSULATOR PROTECTOR

An expulsion type of arrester then was developed consisting essentially of a fiber tube 38 in. long with a wire electrode in each end to reduce the effective arcing length to 30 in., insuring breakdown within the tube. This device was inserted without additional gaps into the line hardware grounding lead. Although these devices have been in use only a comparatively short time they have proved quite satisfactory; eight successful operations have been recorded.

Torok describes in detail some of the difficulties encountered in the development of this device. Some difficulty was encountered in devising assemblies in which breakdown within the tube could be assured. A most promising arrangement was found to be that in which the ratio of internal to external spacing was not greater than 0.85 (see Fig. 27). Some difficulty was experienced also in obtaining proper wall thickness of the tube, since repeated flashovers sometimes caused tube breakdown either by splitting or by puncturing.

In regard to its interrupting characteristics, Torok explains that with an arc established in a cylindrical hole a much higher voltage may be interrupted than if the arc is drawn in the open. If the hole is too small, however, only relatively small currents can be discharged through it. Slepian has shown that the effectiveness of a confining chamber can be increased many times by the use of a material which will produce a gas. With such material the heat of the arc volatilizes the surface of the walls at a rapid rate forcing into the arc stream an appreciable quantity of un-ionized gas. This gas greatly raises the arc voltage and the voltage which can be interrupted. In experimental installations the pressure developed within the tubes by the evolution of gas introduced mechanical difficulties which had to be overcome.

DEIONIZING PRINCIPLES APPLIED

In addition to the mechanical difficulties involved, these tubes often flashed over on the outside because of the convection of ionized gases arising from sparkovers. Deionizing chambers attached to the ends of the tubes have been successful in controlling this condition. The deion principles already have been widely described; the mechanics of this particular application are indicated in Fig. 28.

In designing this tube-type arrester for use on any particular voltage it is essential that the impulse breakdown of the tube be lower than the flashover voltage of the line insulation. Since the breakdown voltage of the tube is governed almost entirely by its length, the maximum internal separation of the electrodes is definitely fixed. The design problem then devolves into one of providing the tube strength required to interrupt arcs normally maintained by the system voltage. For low-voltage protection the design becomes more simple since tube lengths are short and the internal diameters can be reduced without creating dangerously high pressures.

Although still in the experimental stage, development work on this insulator protector is being pushed forward rapidly. It is expected that a practical device which is simple in construction, easy to install, and capable of repeated operation without attention eventually will result.

Lightning versus System Operation

Operating experiences form the final proving ground of the many theories developed; the efficiency of any scheme of protection may be ascertained accordingly. Although one overhead ground wire already is known to be highly beneficial, two are shown to be unquestionably better. Opinions conflict as to the effect of tower footing resistance.

ACCORDING to Sporn's previously mentioned division of the lightning problem as it affects the operation of electric systems, the third part consists of practical operating records covering actual operating experiences where devices and designs for the mitigation of lightning damage are in use. This field experience properly analyzed and interpreted gives the final answer as to the tenability of the many theories developed in connection with lightning and as to the practicability of methods or structures devised to eliminate harmful lightning effects.

Of necessity some of the previous sections of this symposiac have included material which can be classed as operating results. It would be difficult for instance to separate out such results obtained in field investigations of natural lightning where these have been carried on with the lines in operation. Sporn, however, has presented the results of a study made entirely upon the basis of operating records and data and has arrived at certain conclusions based upon the analysis and correlation of those data. This study is a continuation of similar studies made on the transmission system of the American Gas and Electric Company; the data, which were collected in 1929, have been analyzed in the light of previous experiences.

The transmission systems studied have been described in detail in previously published articles. With the exception of a few recent additions the system now comprises 1,198 mi. of 132-kv. lines involving a total of 1,825 circuit miles. It extends from the southern tip of Lake Michigan, southeasterly across the country into northern North Carolina, covering parts of ten states. With one minor exception all lines within the range of observation are of double-circuit steel tower construction with conductors in vertical configuration; all utilize A. C. S. R. conductors, (with a single ground wire of the same material) supported by ten disk units in suspension and twelve on dead ends. Practically all lines are equipped with some sort of arcing protection for insulator strings.

During 1929, 652 observed storms were reported by stations scattered throughout the system. Of these some 565 occurred during the period from April to August inclusive. Recorded lightning outages for the entire system amounted to 133 in 1928 and 248 in 1929. The increase, while due partly to an increase in miles of transmission lines, is attributed largely to the more severe lightning storms which occurred in the region during 1929. A thorough analysis of the operating records and experiences made and interpreted in the light of previous lightning experience on the same system can be summarized as follows:

SUMMARY OF SPORN'S RESULTS

1. Two-circuit lines are better than single-circuit lines.

When installed in vertical configuration on the same towers, the use of two-circuit lines enhances system reliability to proportions greater than does the mere doubling of the circuits. Experience indicates definitely that only from 16 to 29.5 per cent of the trip-outs involve both circuits, and it is likely that this percentage can be reduced by higher speed switching.

2. One ground wire is good; two are better.

The only line equipped with two ground wires had 3.6 outages per 100 mi. of line per year; the only line not equipped with a ground wire had an outage record of 75. A line operating in 1929 with one ground wire had 37.4 outages per 100 mi. of line per year; operating in 1928 with no ground wire this line had the 1929 equivalent of 59.3 outages per 100 mi. of line. This clearly shows the benefits of one ground wire, and definitely indicates that two ground wires are more beneficial than one.

3. Grading shields protect insulators only.

Grading shields have little effect on the lightning outages of these 132-kv. lines; but they definitely limit the damage to insulators and conductors, and reduce the amount of cascading required. Over the entire system (most of the system being equipped with grading shields) 23 per cent of the total number of tower flashovers occurred on cascaded strings. The lines on which grading shields were installed recorded only 21 per cent; lines with no shields, 70 per cent. This is a striking indication of the benefit rendered by grading shields.

4. Misleading conclusions may be drawn.

No interpretation of performance of lines under lightning conditions is possible or of real value without an accompanying record of lightning-storm conditions during the particular time discussed. Otherwise, conclusions gravely misleading may be reached.

5. Only one conductor usually involved.

Records of physical inspection and relay-target indications show that in from 4.7 to 5.8 per cent of trip-out cases due to lightning, all three phases are involved; in from 44.2 to 45.2 per cent, the top and middle conductors only are involved; in from 42.8 to 44.8 per cent the bottom and middle conductors are involved; and in from 78.2 to 64.2 per cent one phase only is involved. This analysis strongly indicates that both direct and induced strokes are of vital importance in the performance of this 132-kv. network.

6. Effect of tower footing resistance problematic.

Detailed data on the tower footing resistances on four 132-kv. lines show no tendency for lightning flashovers to concentrate on towers of high footing resistance in preference to those having low footing resistance. In fact, from these data, whether lightning strikes a tower with low or with high footing resistance seems to be a matter of chance. Flashed-over towers were observed to have footing resistances ranging from 1.5 to more than 250 ohms; and 65 per cent of all recorded flashovers occurred at towers having footing resistances of 20 ohms or less while less than 8 per cent occurred where this resistance was 80 ohms or more.

In general there is close agreement between these conclusions and those arrived at on the basis of the special field investigations. By way of comparison, however, it seems pertinent to mention the following points:

It is generally agreed that efficient ground-wire protection will reduce greatly the number of line outages due to lightning. Bell and Price have found in addition that a counterpoise greatly improves the efficiency of ground-wire protection and thus provides an additional factor of safety, especially where tower footing resistances are high. Fortescue and Conwell state that ground-wire protection near stations should be especially good in order that station equipment (which usually is not as highly insulated as the lines) be provided with the greatest possible amount of protection.

In regard to induced surges versus those caused by direct hits, Bell and Price believe that only in rare cases are induced voltages of sufficient magnitude to cause flashovers on 220-kv. lines. Pittman and Torok in speaking of wood pole lines also state that voltages dangerous to line insulation and equipment in most cases are set up only by direct hits.

There seems to be some disparity in regard to the effectiveness of low tower footing resistance. Fortescue and Conwell report no flashovers on lines equipped with ground wires where footing resistances were less than 5 ohms. Lewis and Foust support this view by calling attention to a 14-mi. 66-kv. double-circuit steel tower line of the Philadelphia Electric Company which has not suffered a lightning interruption for 14 years. This particular line has tower footing resistances of about 4 ohms each and is equipped with two overhead ground wires. Gross and Cox state definitely that an attempt to relate line flashovers to tower footing resistances proved futile while Bell and Price say that the effect of footing resistances higher than 17 ohms seems to be negligible.

Single Patent Appeal Court is Proposed

By
EDWIN J. PRINDLE Patent Attorney
Member A. I. E. E. New York, N. Y.

On the basis of long practical experience the author condemns the present procedure in patent litigation and outlines the foundation for a proposed single United States Court of Patent Appeals which would be second only to the U. S. Supreme Court and would abolish the duplicate and conflicting efforts of the ten district courts in patent matters. Full text of a proposed House of Representatives bill is given.

BECAUSE of the peculiar nature of the patent monopoly, the present system of appeals in patent infringement suits in the United States is the most inefficient, expensive and wasteful to be found anywhere. It is a deterent to the production of inventions, and to the investment of capital in patents. Correction of this condition is by far the greatest need of our patent system.

PRESENT SYSTEM—NATURE AND DEFECTS

For the first century of our patent system, there was a single court of patent appeals, the Supreme Court of the United States. This court became so overburdened with work that, in 1891, the appeal to the supreme court was taken away; and the country was divided into nine circuits (now ten), each of which was provided with a circuit court of appeals, having final and supreme jurisdiction of all patent appeals in its circuit.

These courts are independent of each other. While, under the doctrine of comity and unless they see substantial reasons for not doing so, they follow a previous decision by the court of appeals of another circuit on the same patent, they are at liberty to decide oppositely and frequently do so.

As stated, there is no appeal to the supreme court except that of petitioning that court to grant a writ of certiorari ordering the case to be sent up to it. The supreme court has such an enormous volume of work that it does not take up a patent case unless there is some question of public importance, of interpretation of law, or unless two circuit courts have decided the same question concerning the same patent in opposite ways. The decision of a single circuit court of appeals is final in most branches of the law (practi-

---

Essentially complete text from a pamphlet released May 25, 1931, by Edwin J. Prindle, chairman of the American Engineering Council's patent committee, 111 Broadway, New York, N. Y.

cally the only other exceptions being copyright and trade-mark matters). This is not so as to patents.

The monopoly which a patent grants is a negative one. The patentee is not granted the right, himself, to make, use or sell the patented invention—a *positive* monopoly. He already has that right because of his inventorship, unless in doing so he would have to use that which has already been patented to another. The patent merely grants him the *negative* right to exclude all others throughout the United States, from making, using and selling the patented invention. To be of any value to him, his monopoly must be maintained inviolate. If there is one infringer anywhere in the United States who has been rendered immune from the patent by a final decision, it will greatly impair and may largely destroy the value of the patent. One hole that cannot be stopped may sink a ship.

Under these circumstances, to make it necessary that the patent shall have been adjudicated oppositely in two separate circuit courts of appeal before the mere right shall exist to petition the one court which can render a final decision, the supreme court, to take it up is a shocking economic waste. A patent may be valid in one circuit and invalid in another. It may have been given a broad, inclusive, interpretation in one circuit, and a narrow one in another. It may be infringed by a given construction in one circuit, and not infringed by the same construction in another. A defendant in whose favor a patent in one circuit has been held invalid, or not infringed, is free to make, use, and sell in every other circuit; the patentee cannot even enjoin his agents or customers. Thus, in a single circuit, a patent may be invalid as to one person or corporation and valid as to everyone else, or *vice versa*. Even if a patent has been sustained in two circuits, there still are eight circuits, any one of which could decide to the contrary.

If the first of two decisions by a different circuit court of appeals is against a patent, and the supreme court decides in favor of the patent, it almost invariably is too late for the decision of the supreme court to affect the first case; and the defendant in that case is free to infringe the patent throughout the remainder of its life and throughout the whole country. Furthermore, the statute provides that where the patent covers more than the patentee invented he must, with reasonable promptness, file a disclaimer in the U. S. Patent Office disclaiming that which is not his invention. Where in the first suit under the patent a court of appeals holds a claim to be invalid, it must promptly be disclaimed under penalty of the patentee losing the right to bring other suits under the patent. The law provides that the disclaimer becomes a part of the patent, and is effective throughout the United States in all circuits. Thus patents may be nullified irretrievably because of a plurality of courts of appeals. With a single Court of Patent Appeals, the validity of the claims could be finally determined before any disclaimer was filed. Moreover, by the time the patentee has obtained a favorable decision in a second circuit in any of these cases, much of the short life of the patent (seventeen years) usually has expired with no substantial reward to the inventor. Expenses of these repeated litigations make them impossible to the individual, and constitute a burden from which even large corporations shrink.

With ten courts of appeals there are unavoidable differences of opinion on various points of law and differences of tradition as to the liberality or strictness of construction to be applied to a patent under the same circumstances. Under a single court of patent appeals the administration of the patent law would attain completeness and certainty and uniformity of application now lacking in these and other respects. Patents also involve many difficult questions of science and engineering, upon which judges may and often do differ. Thus it is impossible for the decisions of various circuit courts of appeals on the same patent always to be uniform.

Quite as many adjudicated patents are held to be invalid as are sustained. Both the public and the patentee, therefore, need to know early in the life of the patent whether or not the patent is valid, and what is its scope. If the patent is invalid the public should know it through a single final decision, and not be kept in uncertainty for years during which it would have been free to use the alleged invention described in the patent. However, if a patent is valid, the patentee early in the life of his patent should have a single decision which applies throughout the United States and which would hold against all subsequent defendants, unless they set up defenses substantially different from those considered in the first suit, or unless they use a structure outside the monopoly of the patent as determined in the first suit.

The patent should be adjudged as to validity, scope and infringement, on the same principles and policy throughout the United States, both for the sake of the public and the patentee. The head of the patent department of one of the largest corporations in this country said to the writer recently, "Whether a patent is valid or invalid, we want, early in its life, to know definitely so that we may shape our course accordingly and with confidence that the situation will not be changed during the life of the patent, except for substantial reasons."

The only solution of the difficulty is a "single court of patent appeals."

HISTORY OF LEGISLATIVE EFFORTS

In 1903 the American Bar Association approved the principle of a report of its patent committee recommending the establishment of a single court of patent appeals, and directed that committee to lay a bill for that purpose before Congress. The particular bill then proposed was not approved, but the principle of a single court of patent appeals was approved, leaving the form of the bill open. Mr. Frederick P. Fish was chairman of the patent section, and vigorously advocated the bill, which provided for a chief justice, appointed for life, and six judges chosen from the circuit and district courts to sit for terms of six years each.

Both the 1903 attempt and a subsequent attempt made in 1919 failed, however. The House Committee refused to approve the bill because it became apparent that judges would not break up their homes and interrupt their friendships and their children's schooling and go to Washington merely for a term of six or possibly twelve years. It became clear that appointments would have to be permanent to induce judges to become members of the proposed court.

Meanwhile, the need for a single court of patent appeals has been growing constantly. Such a court is now a practical necessity. It would substantially stimulate inventing and would protect both the patentee and the public from enormous unnecessary expense.

The American Engineering Council recently has approved renewing the legislative effort with a bill curing the former objections. The National Association of Manufacturers again has passed a resolution approving of the principle of a single court of patent appeals, and the undertaking of another campaign at this time to enact a bill for the purpose. Also, various committees of patent law associations are considering the advisability of a renewed effort to secure a single court of patent appeals.

PROVISIONS OF PROPOSED BILL

The writer has prepared a bill which provides for a single court of patent appeals sitting at Washington, and composed of a chief justice and six associate judges, five of the seven judges to constitute a quorum. Not only the chief justice, but the associate judges are to be appointed, as the Constitution says, "during good behavior." The proposed court is to have final jurisdiction of all appeals in patent cases from the District Courts of the United States and from the Supreme Court of the District of Columbia, both in interlocutory and final orders and decrees, jurisdiction of the United States Circuit Courts of Appeals in patent appeals being abolished. The power of the Supreme Court of the United States to order cases certified to it, is extended to include the proposed single court of patent appeals, and the right is given to that court to certify questions to the Supreme Court for instructions.

Salaries of the chief justice and the associate judges of the single court of patent appeals as proposed are $13,500 for the chief justice, and $13,000 for the associate judges. These are higher than those of the circuit courts of appeals, thereby ranking the single court of patent appeals next to the Supreme Court of the United States. This undoubtedly would assure that a sufficient number of the best qualified judges in patent cases will be available for appointment to the proposed court.

That the judges shall be specially qualified for the adjudication of patent cases in the single court of patent appeals, the bill provides that "experience in the adjudication of a substantial number of patent cases on the federal bench, or in the practise of patent law in the federal courts, shall be requisite to appointment as chief justice or a judge of said court, to the end that only judges who have shown special aptitude for the adjudication or the practise of the patent law shall be appointed to said court." Further experience and observation show that, by the adjudication of many patent cases, they would acquire a facility for comprehending the science and engineering of patent cases which would enable them, to a much greater extent, to make a selection on their own judgment between the conflicting opinions of experts.

The proposed bill changes the name of the court of customs and patent appeals to the "court of customs and patent office appeals," and it does not provide for appeals therefrom to the single court of patent appeals. However, an applicant for a patent (in every case except where the commissioner of patents is a necessary party, instead of appealing from the commissioner of patents to the court of customs and patent appeals) could reach the proposed single court of patent appeals by appeal on a bill in equity filed in the Supreme Court of the District of Columbia or, where the opposing party in the interference is not a resident of the District of Columbia, by an appeal on a bill filed in the district court of the district of which his opponent is a resident.

The establishment of a United States Court of Patent Appeals not only would be a great benefit to patentees and to the public, but will increase the effectiveness of patents, and prolong the productive portion of their terms. It would also substantially stimulate inventiveness and the building of businesses under patents. Establishment of the U. S. Court of Customs Appeals (now the U. S. Court of Customs and Patent [Office] Appeals) affords a precedent for the establishment of a single U. S. Court of Patent Appeals.

It is believed to be entirely possible to secure the establishment of a single court of patent appeals at this time if sufficient support is given by those who realize the importance of the patent system to the United States.

Attention is invited to the following draft of the proposed bill for a single court of patent appeals, the principal provisions of which have just been outlined.

COMPLETE TEXT OF PROPOSED H. R. BILL

IN THE HOUSE OF REPRESENTATIVES

A BILL

To Establish a Single United States Court of Patent Appeals, To Change the Name of the United States Court of Customs and Patent Appeals, and for Other Purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that there is hereby created an United States Court of Patent Appeals, which shall consist of seven justices, of whom five shall constitute a quorum, and shall be a court of record with jurisdiction as is hereinafter limited and established. Such court shall prescribe the form and style of its seal and the forms of its writs and other process and procedure as may be conformable to the exercise of its jurisdiction as shall be conferred by law. It shall have the appointment of the marshal of the court, who shall have the same powers and perform the same duties under the regulations of the court as are now provided for the marshal of the Supreme Court of the United States, so far as the same may be applicable. The Court shall also appoint a clerk, who shall have the same powers and perform the same duties now possessed and performed by the clerk of the Supreme Court of the United States, so far as the same may be applicable. The salary of the marshal of the court shall be $3,500. a year, and the salary of the clerk shall be $5,000. a year, both to be paid monthly in twelve equal payments. The costs and fees now provided by law in the Supreme Court of the United States shall be the costs and fees in the United States Court of Patent Appeals; and the same shall be collected, expended, accounted for, and paid over to the Treasury Department of the United States in the same manner as is provided by law in respect to the costs and fees in the Supreme Court of the United States. The Court shall have power to establish all needful rules and regulations for the conduct of its business within its jurisdiction as conferred by law.

Sec. 2. That the President of the United States, by and with the advice and consent of the Senate, shall appoint a chief justice, and six associate justices of said United States Court of Patent Appeals, and as vacancies occur shall in like manner appoint others to fill such vacancies from time to time. The acceptance of one of said offices by a circuit or district judge of the United States shall vacate his office as circuit or district judge. Experience in the adjudication of a substantial number of patent cases on the Federal bench or in the practice of the patent law in the Federal courts shall be requisite to appointment as chief justice or an associate justice of said court, to the end that only judges who have shown special aptitude for the adjudication or the practice of the patent law shall be appointed to said court. Appointment to said court shall be during good behavior.

Sec. 3. That a term of the United States Court of Patent Appeals shall be held annually at the City of Washington, beginning on the second Tuesday of October in each year, and the same may be adjourned from time to time as the court shall order. If at any time for the meeting of the court a quorum of the justices shall not be present, the justices present may adjourn the court and, if necessary, adjourn again from time to time until a quorum appear. If at any sitting of the Court, the Chief Justice shall be absent, the associate justice senior in commission as a circuit judge, or senior in age in case of commissions of even date, shall preside. If no associate justice who has been a circuit judge shall be present, the associate justice senior in commission as a district judge shall preside. In case of commissions of even date, the justice who is senior in age shall preside. Upon a request of the Chief Justice, or a presiding associate justice of The Court of Patent Appeals, the Chief Justice of the United States shall designate a judge, or judges, of any federal court to fill a temporary vacancy in the said Court of Patent Appeals. Until it shall otherwise be provided by Congress, the sessions of the court shall be held in a building or rooms to be provided by the marshal of the District of Columbia, under the direction and approval of the Attorney General of the United States. The court shall by order authorize its marshal to employ such deputies and assistants for himself and the clerk of the court and such criers, bailiffs, and messengers as the business of the Court shall require, and to pay the salaries of such employees at rates of compensation not exceeding those paid for similar services in the Supreme Court of the United States, and to pay all other necessary incidental expenses of the court. The Chief Justice and each of the Associate Justices shall be entitled to employ a clerk, whose salary, at a rate not exceeding that allowed the clerks of the Chief Justice and associate justices of the Supreme Court, shall be paid as part of the expenses of the Court. The Court shall have power, in its discretion, to appoint a reporter and to fix by order his salary or other compensation and direct the form and manner of the official publication of its decisions.

Sec. 4. That the Chief Justice of the United States Court of Patent Appeals shall receive a salary of $13,500. per year. The Associate Justices of the said court shall each receive a salary of $13,000. per annum. All the said salaries shall be payable in twelve equal monthly installments. The time during which any Justice shall serve in said court shall be deemed continuous service with that in any other court of the United States, before or after such service within the meaning and intent of Section Three Hundred and Seventy-five of title Twenty-eight of the United States Code.

Sec. 5. That the United States Court of Patent Appeals shall have jurisdiction to hear and determine appeals from final judgments and decrees in the district courts of the United States and in the Supreme Court of the District of Columbia in cases arising under the laws of the United States relating to patents for inventions, and from final judgments and decrees in cases arising under the laws of the United States relating to patents for inventions rendered by any other court having jurisdiction under the laws of the United States to hear and decide such cases in the first instance: Provided, however, that it shall have no jurisdiction of cases originating in the Court of Claims nor of cases in which the Commissioner of Patents is a necessary party. All such appeals shall be taken within three months after the entry of the order, judgment, or decree sought to be reviewed. The practice, procedure, and forms to be observed in the taking, hearing and determination of such appeals shall conform to the practice, procedure, and forms observed in like cases in the Supreme Court of the United States, subject to such rules and regulations as shall be prescribed by the Court. The said Court shall have power to prescribe the forms of records on appeals thereto.

Sec. 6. That whenever, by an interlocutory order or decree in a district court of the United States, in the Supreme Court of the District of Columbia or other Court having jurisdiction under the laws of the United States to hear and decide in the first instance cases arising under the patent laws, in a case in which an appeal may be taken from the final decree of such court to the United States Court of Patent Appeals, an injunction or restraining order shall be granted, or refused, or continued, or vacated, or modified, or retained without modification after motion to modify the same, an appeal may be taken from such order or decree by the party aggrieved to the United States Court of Patent Appeals: Provided, That the appeal must be taken within thirty days from the service of notice of entry of such order or decree; and it shall take precedence in the appellate Court; and the proceedings in other respects in the court below shall not be stayed unless otherwise ordered by that court, or the United States Court of Patent Appeals, or a judge thereof, during the pendency of such appeal.

Sec. 7. That the chief justice and the associate justices of the United States Court of Patent Appeals shall each exercise the same powers in term and vacation in the allowance of appeals, supersedeas orders, and other matters incidental to the jurisdiction and business of the Court as are now exercised by the Chief Justice and associate justices of the Supreme Court of the United States in relation to the business and jurisdiction of that Court.

Sec. 8. That the decisions of the United States Court of Patent Appeals in all cases within its appellate jurisdiction shall be final, except that it shall be competent, as hereinafter provided for the Supreme Court of the United States to require, by certiorari, or otherwise, any such case to be certified to it for its review and determination with the same power and authority in the case as though it had been carried by appeal from the trial court directly to the Supreme Court.

Sec. 9. That whenever any case shall have been certified from the United States Court of Patent Appeals to the Supreme Court of the United States, by certiorari or otherwise, it shall, upon its determination by the Supreme Court, be remanded to the district court of the United States or other court in which it originated for further proceedings to be taken in pursuance of such determination. And in every case determined by the United States Court of Patent Appeals upon appeal, the case shall be remanded to the District Court of the United States or other Court from whence it came, for further proceedings to be taken in pursuance of such determination.

Sec. 10. That all appeals in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall have been pending without hearing in the United States Circuit Courts of Appeals or other court of appellate jurisdiction for less than three calendar months prior to the taking effect of this Act shall be transferred from such circuit courts of appeals or other courts to the United States Court of Patent Appeals and be heard and determined in that court as though they had been taken there from the trial courts by appeal without further payment for certifying the record or any new or additional docket or calendar fee; all other appeals and writs of error in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall be pending in the United States circuit courts of appeals or other courts of appellate jurisdiction at the time of the taking effect of this Act shall remain and be heard and determined by the courts in which they may be pending, respectively, as though this Act had not been passed.

Sec. 11. That after the taking effect of this Act no appeal shall be taken from any district court or from the Supreme Court of the District of Columbia or other Court of the United States to any United States circuit court of appeals or other appellate court in any case in which an appeal may be taken to The United States Court of Patent Appeals under the provisions of this Act. If, in any case, it is found that no substantial question under the patent laws is raised by the appeal, the court may order that such appeal be sent to the circuit court of appeals having jurisdiction over the district in which the suit was brought, or the Court of Appeals of the District of Columbia, as the case may be; if any appeal shall be taken to any circuit court of appeals, or to the Court of Appeals of the District of Columbia, and such court shall find that such appeal involves a question arising under the patent laws of the United States, except in a case where the Commissioner of Patents is a necessary party, such court shall order such appeal to be sent to the Court of Patent Appeals, and no appeal shall be dismissed solely on the ground that the appeal has been taken to the wrong court.

Sec. 12. Section 301a of Title 28 of the United States Code is hereby amended to read as follows:

> The title of the United States Court of Customs and Patent Appeals, created by Section 301 of this title, is hereby changed to The United States Court of Customs and Patent Office Appeals.

Sec. 13. Section 346 of Title 28 of the United States Code is hereby amended to read as follows:

> In any case, civil, or criminal, in The United States Court of Patent Appeals, in a Circuit Court of Appeals, or in the Court of Appeals of the District of Columbia, the Court may at any time certify to the Supreme Court of the United States any questions or propositions of law concerning which instructions are desired for the proper decision of the cause; and thereupon the Supreme Court may either give binding instructions on the questions and propositions certified or may require that the entire record in the cause be sent up for its consideration and thereupon shall decide the whole matter in controversy in the same manner as if it had been brought there by writ of error or appeal.

Sec. 14. Paragraph (a) of Section 347, Title 28 of the United States Code is hereby amended to read as follows:

> (a) In any case, civil or criminal, in a circuit court of appeals, or in the United States Court of Patent Appeals, or in the Court of Appeals of the District of Columbia, it shall be competent for the Supreme Court of the United States, upon the petition of any party thereto, whether Government or other litigant, to require by certiorari, either before or after a judgment or decree by such lower court, that the cause be certified to the Supreme Court for determination by it with the same power and authority, and with like effect, as if the cause had been brought there by unrestricted writ of error or appeal.

Sec. 15. That Sec. 377, Title 28 of the United States Code, be amended to read as follows:

> "Power to issue writs. The Supreme Court, and the District Courts shall have power to issue writs of *scire facias*. The Supreme Court, the Court of Patent Appeals, the Circuit Courts of Appeals, and the District Courts shall have power to issue all writs not specifically provided for by statute, which may be necessary for the exercise of their respective jurisdictions and agreeable to the usages and principles of law."

Sec. 16. That all laws and parts of laws inconsistent with the provisions of this Act are hereby repealed.

Sec. 17. That this Act shall take effect and be in force on the day of nineteen hundred and

---

Twin Motors for Heavy Rolling Mills

By
R. H. WRIGHT Member A. I. E. E. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
H. E. STOKES Non-member Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Twin-motor drive has met effectually the repeated demands for more power at the rolls. Other advantages, however, which now far overshadow the improvement originally sought are the direct outcome of the reduced inertia and greater operating flexibility inherent in this type of drive.

TWIN-MOTOR DRIVE for heavy blooming and slabbing mills has grown out of an increasing demand for power at the rolls greater than can be provided conveniently by conventional design methods. At the same time, this new development is a logical step in the modern trend toward greater mechanical simplicity in rolling-mill machinery. Already two machines, one a 54-in. blooming mill, the other a 44-in. slabbing mill, each with main rolls driven by independent motors, are in successful operation.

The principal advantages which these installations have exhibited can be summarized as follows:

1. Greatly increased motor capacity may be applied to a single pair of rolls.
2. Pinion losses with their attendant repair and maintenance are eliminated.
3. Twin motors may be designed to have greatly reduced inertia. This means less strain on equipment, more torque available for useful work, reduced motor and generator heating, and greater acceleration.
4. Roll chatter and spindle vibration are practically eliminated.
5. Higher rolling speeds can be maintained and mill tonnage can be increased.

The term "twin-motor" has come to refer to a form of rolling-mill drive in which each of a pair of rolls is independently driven by a separate motor. In a true twin-motor drive the motors may not operate at exactly the same speed at all times; nor do they depend entirely upon the coupling effect of the metal being rolled to maintain correct load division and speed relations.

Independent drive for the working rolls has been used previously in wheel and tire mills, piercing mills, and tube expanders and reelers. In these installations the motors rotated in one direction only at practically constant speed, the metal between the rolls providing an

---

From "Twin-Motor Drive," presented at the convention of the Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, Jun 15-19, 1931. A. I. & S. E. E. headquarters, 1010 Empire Bldg., Pittsburgh, Pa.; J. F. Kelly, managing director.

effective coupling and rather definitely fixing the speed and load relations. Reversing-beam mills with independently driven edging rolls also were in successful operation. Here experience demonstrated that the speed relations of two reversing motors working on the same piece of steel could be adjusted to take care of varying drafts with no indication of unusual roll slippage.

When the electrical equipment for the 54-in. blooming mill first was considered it was felt that, to provide power for rolling heavier sections at higher tonnage rates, the continuous capacity and maximum torque of the reversing motor should be greater than had been used previously.

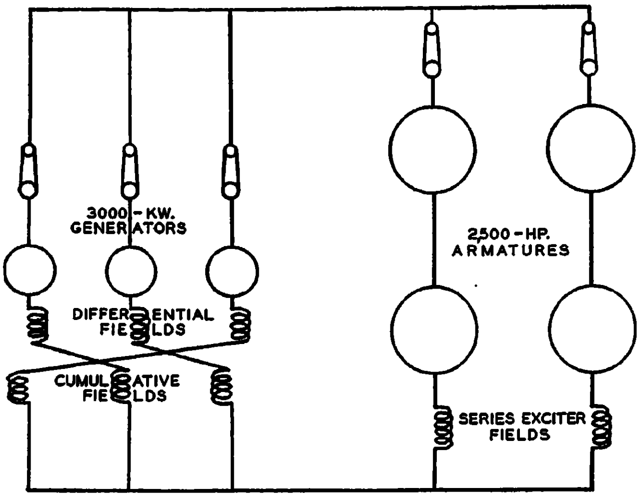


Fig. 1. Main connection diagram for 10,000-hp. twin-motor drive and associated generators

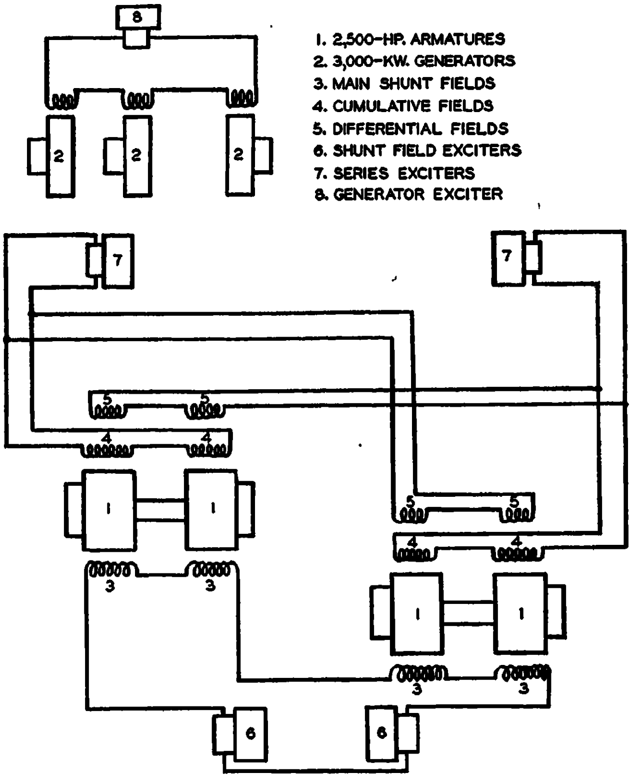


Fig. 2. Field-circuit connections for 10,000-hp. twin-motor drive

Accordingly both 10,000- and 12,000-hp. equipments with maximum torques of 3,940,000 and 4,725,000 lb-ft. respectively were considered, since a duplicate mill already had been built with an 8,000-hp., 50-r. p. m. drive having a rated maximum torque of 2,500,000 lb-ft. It was thought then that for the higher motor torques the drive for the new mill could be improved mechanically by eliminating the mill pinions. This mechanical improvement now has been realized but other advantages as outlined in the beginning so far outweigh those expected that what previously were considered foremost, now seem insignificant. This, of course, is the usual story of many new developments.

Design Difficulties Involved

Design of reversing equipments for machines of this size presents some interesting problems. A motor with a single-unit armature would have the advantages of simplicity and comparatively high efficiency. However, the maximum capacity which so far has been built into a single-unit armature is 8,000 hp. at 40 r. p. m., and a motor of this size has an armature which approaches the largest that can be shipped in one piece. Using present design proportions, about 10,000 hp. continuous capacity at 40 r. p. m. with 3,300,000 lb-ft. maximum torque would be the largest motor which could be built with a single-unit armature. The inertia of such a motor, however, would be tremendously high—in fact about 2.3 times that of the 10,000 hp. twin-motor drive finally adopted.

A double-armature motor offers the next best possibility for a single machine of 10,000- or 12,000-hp. capacity at a speed of the order of 40 r. p. m., but even in this type of machine, the inertia would be nearly twice that of an equivalent twin-motor drive. Construction of the electrical equipment for high-capacity reversing drives thus obviously is somewhat more complex than for small and medium ratings.

In addition to the disadvantages of large single-motor drives already mentioned, pinion stands suitable for transmitting torques of from 4,000,000 to 5,000,000 lb-ft. become extremely large and heavy and their design and manufacture involve serious mechanical problems. For large mills, therefore, the twin-motor drive offers both mechanical and electrical advantages.

The twin-motor drive finally selected for the 54-in. blooming mill consists of two 5,000-hp., 40/80-r. p. m. double-armature motors with a combined maximum torque rating of 3,940,000 lb-ft. Each armature is wound for 350 volts, the two armatures of one motor being connected in series, as shown in Fig. 1. The two motors operate in parallel and receive power from three

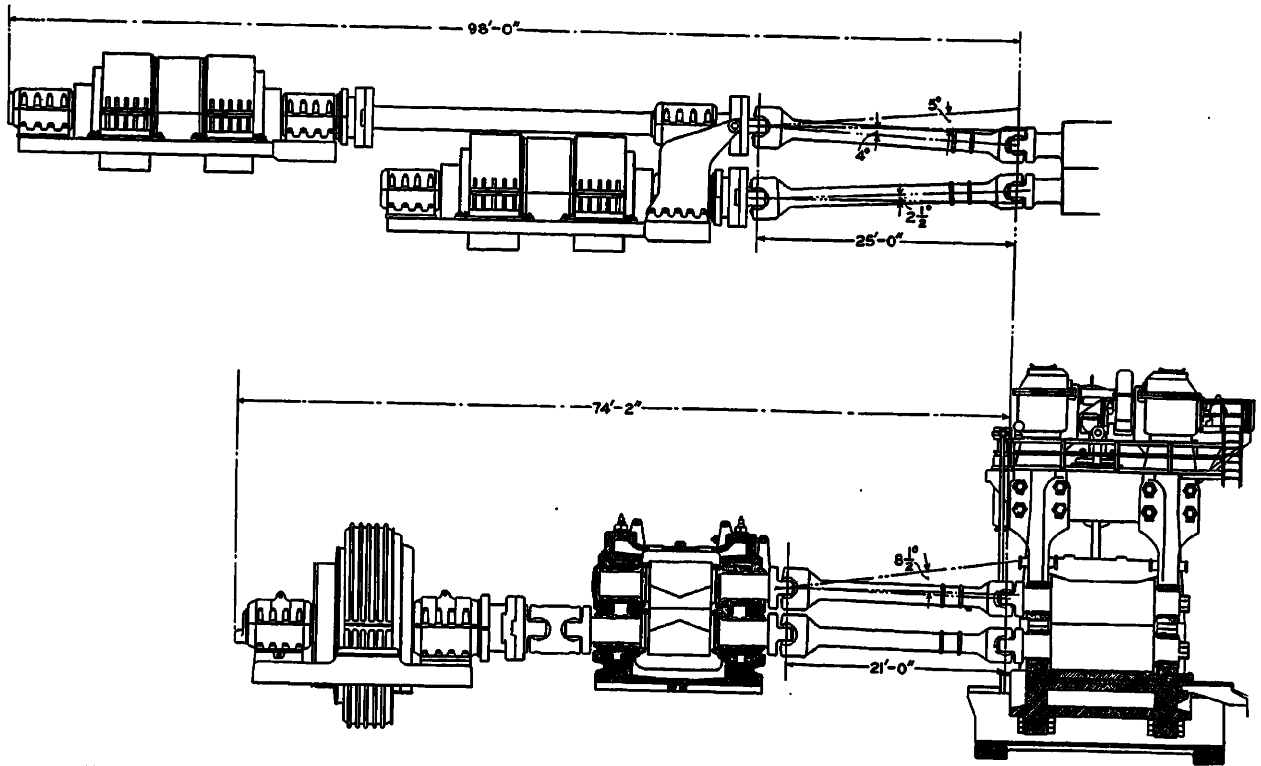


Fig. 3 General layout of 10,000-hp. twin-motor drive (above) and 8,000-hp. single-motor pinion drive (below) for 54-in. blooming mill. Note comparative space requirements

3,000-kw., 700-volt generators, also connected in parallel. The motor-generator is equipped with a 90-ton, 15-ft. diameter steel-plate flywheel, and is driven by a 6,500-hp., 368-r. p. m. induction motor.

Electrical Features

A diagram of the field circuit showing the method of field control may be seen in Fig. 2. All shunt fields of both double-armature motors are connected in series, thus insuring the same shunt-field excitation for both motors. As may be noted, two shunt-field exciters are employed for the motors in order to permit the use of standard 250-volt exciter generators. This arrangement also makes possible the variation of the relative shunt excitation of the two mill motors, if necessary, by means of a buck-and-boost exciter connected across the mid-point of the field circuit and a point midway between the two exciters. Up to the present time, however, no occasion has been found to make use of this latter feature.

In addition to the main shunt-field winding each motor is equipped with a cumulative series field and a differential series field which are cross-connected and indirectly excited by series exciter generators. As shown in Fig. 2 each series exciter generator has its series field in the armature circuit of one double-armature motor, and excites the cumulative field of that motor and the differential field of the other motor. Hence any tendency of one motor to take more than its share of the load strengthens its field and weakens the field of the other motor, thus quickly reestablishing equilibrium.

With this load-balancing scheme, any desired speed regulation can be obtained without interfering with the load-balancing characteristics—a valuable feature indeed. Of note also is that the load-balancing effect can be varied without affecting the compounding.

A similar scheme is used to balance the loads on the three generators of the motor-generator set except that the generator series fields are excited directly without the use of series exciters, and that each generator excites its own differential field and the cumulative field of the adjacent generator.

Mechanical Features

Mechanical arrangement of motor, spindles, and rolls is shown in Fig. 3. The motors are mounted on on 83.5-in. centers. Relative elevations of motors and rolls are such that the lower spindle operates at an angle of 2.5 deg.; the upper spindle runs at an angle of 4 deg. below horizontal when the rolls are together and 5 deg. above horizontal when the rolls are set for their maximum separation. The mill spindles are 25 ft. long, which is 4 ft. greater than for a duplicate mill with pinions. The maximum angle of the upper spindle for the pinion drive, corresponding to the same roll separation, is 8.5 deg.

Comparative space requirements and spindle angles for an 8,000-hp., 40-r. p. m. drive with pinions, and for a 10,000-hp., 40-r. p. m. twin-motor drive are shown also in Fig. 3. As may be noted with the pinion drive, the spindles operate under the most favorable conditions when the rolls are close together. Usually, however, loads are heaviest when the ingot being rolled is large and the upper spindle considerably inclined. With twin-motor drive the spindle angle is at minimum when the rolls are separated considerably; hence with this type of drive the best operating conditions obtain when the load is at maximum.

Mechanically, the two motors of a twin drive are identical. The mill-end pedestal of each motor is supported on a heavily ribbed cast steel baseplate. The sides and front end of the bedplate are fabricated in the usual manner from heavy beams and slabs. The upper motor drives through a jack shaft, an "A" frame on the mill end of the lower motor supporting a pedestal bearing which carries the outer end of this shaft. Thrust in this jack shaft is taken care of by the mill-end pedestal of the upper motor. The lower motor is provided with the usual type of thrust bearing. Both the motor shafts and the jack shaft have forged flanges. Driving halves of the universal couplings next to the motors are bolted to the shafts in such a way that they can be removed for renewal or repair. Electrical construction of the motors is in accord with accepted practise for reversing service.

CHARACTERISTICS OF TWIN- VS. SINGLE-MOTOR DRIVES

Operating characteristics of the 10,000-hp. twin-motor drive are quite different from those of a conventional reversing equipment driving through pinions. These differences are indicated in the following comparisons.

1. Quieter operation.

Steel enters the rolls without shock. The usual vibration and noise in the mill spindles are absent, and there is practically no tendency for the mill to chatter. Consequently the roller is not required to exert the usual care but can enter the steel on the first trial, even at higher speed thereby saving time on the early breakdown passes.

2. Greater operating flexibility.

In the pinion drive, independent movement of the rolls is limited by the back-lash in the pinions and spindles; this limitation of movement constitutes the chief cause of roll chattering. With twin-motor drive the phase positions of the rolls can shift independently thereby quickly adjusting themselves to the steel and largely eliminating roll chatter.

3. Higher mill acceleration and retardation.

Comparatively low inertia in the motors allows the control to be designed for unusually fast field response without setting up high reverse power currents. Electrical equipment is therefore used to better advantage and the capacity for useful work is increased.

4. Intervals between passes reduced.

This is brought about by the rapid response of the motors which not only makes the handling of the drive much easier than the usual drive, but also permits the steel to be kept closer to the mill.

5. Total rolling time decreased.

The quick response of the motors increases the entering and average rolling speeds, thereby decreasing the rolling time by increasing the percentage of the time the metal is in the rolls.

Twin-motor drive also has been applied recently to the main horizontal rolls of a 44-in. slabbing mill. This mill is similar to that of the 54-in. blooming mill except that the total capacity of the drive is greater. The main horizontal rolls are driven by a 10,000-hp., 40/80-r. p. m., twin-motor drive similar to that just described. The vertical rolls are driven separately by a 2,500-hp. 79/225-r. p. m. 700-volt reversing motor. The flywheel motor-generator comprises three 3,500-kw. 700-volt generators but otherwise is the same as the blooming-mill set.

TWIN MOTORS FOR SMALLER MILLS

The two installations just described are the first applications of twin-motor drive to heavy-duty mills and in addition represent the greatest power which so far has been applied to a single pair of rolls. For mills with 40-in. or smaller rolls requiring motor capacity of 8,000 hp. or less, the drive usually can be simplified by building each motor with a single armature. The smaller motors can be mounted on smaller centers and the spindle angles can be kept within reasonable limits without making the spindles excessively long.

It is possible from both the mechanical and electrical

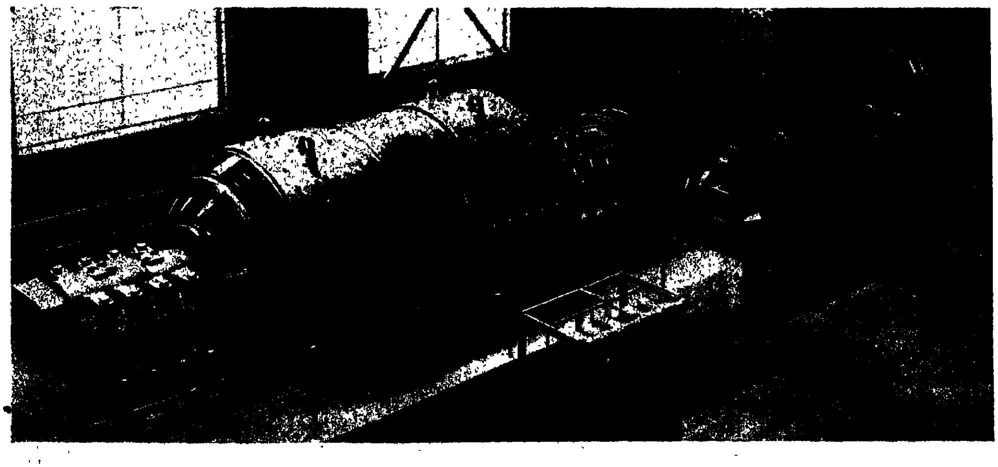


Fig. 4. General arrangement of the two 5,000-hp. double-armature motors as actually installed

standpoints to build a reversing mill drive with one motor on each side of the mill. With this arrangement small motor diameter is not an important consideration and the motors can be designed along conventional lines; where both motors are located on the same side of the mill, however, motor design may be somewhat special. However, within reasonable limits, electrical construction details are relatively flexible and each individual installation therefore should be laid out to fit local conditions most advantageously.

Cost and Other Considerations

Relative first costs of twin-motor reversing drive and pinion drive will vary with the size and torque requirements of the mill. The motors of a twin-motor drive with the necessary shafting and bearings are more expensive to build than a single motor of equivalent capacity. This increased cost may be somewhat less than the cost of a pinion stand with spare pinions and bearings for a heavy mill, but somewhat greater than these costs for a light mill. In general, however, the difference in cost is not great and is far outweighed by the many advantages of twin-motor drive.

Twin-motor drive offers advantages also for wide strip mills, whether these are used for hot or cold rolling. The chief advantage in this application is that the elimination of the mill pinions does away with the necessity for accurate matching of the mill rolls. When single-motor drive is used for either hot or cold rolling, unless the rolls are matched accurately, high stresses are set up in the pinions in order that the larger roll will slip and equalize the delivery speeds. With twin-motor drive the motor speeds readily adjust themselves so that each roll has the same surface speed. The problem of load division is quite simple, since wide thin material forms practically a perfect coupling between rolls.

The simplest form of drive for a strip mill is one having a direct-connected motor on either side of the mill, each motor driving one working roll. To this arrangement there may be objections, especially in hot-rolling mills, on account of the space occupied by the motor and spindles on the side of the mill usually left open. This objection can be overcome by the use of special gearing which will permit the installation of both motors on the same side of the mill. And since geared motors with pinion drive are now the usual thing, such an arrangement would introduce no new mechanical complications. The total number of gear units would remain the same, and instead of one reduction unit and one mill pinion unit, each of full capacity, there would be two reduction units, each of half the total capacity.

In recent years the conceptions of steel plant executives and engineers as to the expected output of various sizes and types of mills have become fairly well standardized. Certain standards also have been applied in selecting the electric drives. Where twin-motor drive is to be used, a revision of standards obviously will be necessary. Higher average rolling speed and the reduction of intervals between passes allow the capacity of such a mill to be increased over what would be expected from one with the conventional single-motor drive. The net result is a more advantageous utilization of electrical equipment in the twin-motor drive; hence a greater tonnage output can be realized with no increase in motor capacity. Moreover, in many cases it will be desirable to provide still greater motor capacity than now is customary in order to take advantage of every possibility for increased output.

A Vacuum-Tube Device for Current-Balance Telemeters

The motor-operated rheostat with its associated apparatus now is replaced by a simpler, more compact vacuum-tube arrangement. The only auxiliary power required can be obtained from an ordinary station-lighting circuit; circuit constants are chosen so that momentary dips in this supply voltage do not affect the readings.

By
B. E. LENEHAN Westinghouse Elec. & Mfg. Co., Newark, N. J.
Associate A. I. E. E.
PAUL MacGAHAN Westinghouse Elec. & Mfg. Co., Newark, N. J.
Member A. I. E. E.

AN IMPROVEMENT for current-balance telemetering systems recently has been devised, not only to eliminate the auxiliary motor and special rheostat now commonly used with this apparatus but also to render unnecessary an additional source of d-c. supply. This new improvement utilizes electron tubes for producing and controlling the feeble direct current which constitutes the indicating medium for this type of remote metering.

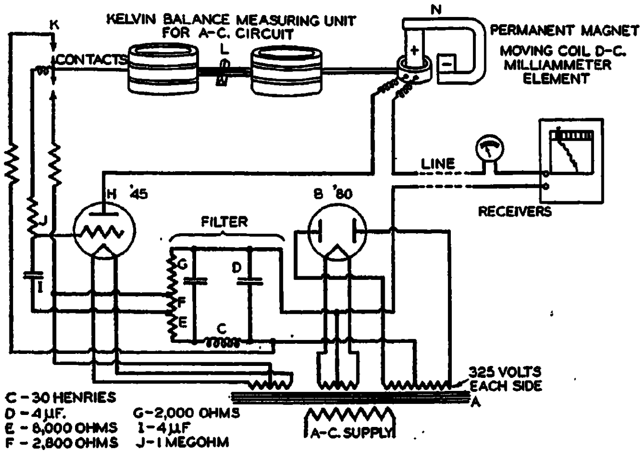
In general, telemetering systems are capable of a wide variety of applications including not only measurements of electrical quantities but also of many mechani-

---

Written specially for Electrical Engineering; not published in pamphlet form.

cal entities; for example, water-level indications in unattended hydroelectric stations. In the *current* type of apparatus as contrasted with other types the variations to be remotely observed are first translated into proportional currents; these are then transmitted over communication lines and measured at the remote receiving point by the usual type of current measuring instruments.

The current-balance system constitutes one particular species of current telemeter, utilizing a mechanism in which a direct current of *milliampere* magnitude is regulated to be proportional to the quantity being measured; this small direct current then being transmitted to the remote receiving point. As previously constructed the transmitter in this system consisted essentially of a composite a-c.—d-c. balance mechanism in which the torque of a-c. measuring coils was balanced against the counter-torque of d-c. coils. Current in the d-c. coils was adjusted by a motor operated rheostat, the motor in turn being actuated by contacts on the balance mechanism.



Schematic diagram of new vacuum-tube transmitter for current-balance telemetering

A schematic diagram of the new electron-tube current-balance transmitter may be seen in the accompanying illustration. Power, voltage, current, or whatever entity is to be remotely indicated is applied to the measuring element *L* and produces a torque tending to close one of the contacts *K*. An electromagnetic counter-torque is established by the d-c. element *N*, which carries the telemeter current in the communication line, this of course being the current measured by the remote receiving meters. These two torques are applied against each other by the composite a-c.—d-c. balance mechanism *L-N*. If they do not balance exactly, contacts *K* operate to adjust the direct current (which is supplied from the plate circuit of tube *H*) to the balancing value. When the upper contacts close, the grid voltage of tube *H* is increased and the plate circuit is correspondingly reduced; when the lower contacts close, the grid voltage is reduced thereby increasing the plate current. The resistance *J* slows down the charging time of the condenser *I* enough to allow the balance *L-N* to open the contacts and stop charging when the proper current value is reached.

Power is obtained for the electron tubes and associated equipment from an auxiliary a-c. supply such as a station lighting circuit. Transformer *A* supplies filament voltages to both tubes, and plate voltage to rectifier tube *B*. This latter tube supplies the d-c. plate and grid voltages for tube *H* through filter circuit *C-D* and resistor *E F G*.

Resistances *E*, *F*, and *G*, are so chosen that *G-F* will produce enough grid voltage to reduce the plate current to zero, when voltage equivalent to the drop on *G* is impressed on the plate. The resistance *F* is so chosen that when a sudden change occurs in the line voltage of the auxiliary supply *A*, no change in the plate current of tube *H* takes place. Thus this resistor arrangement prevents line supply dips from showing on the record, and thereby overcomes a condition existing in previous forms of current-balance systems.

Use of electron tubes in this apparatus eliminates all moving parts used previously, excepting of course those associated with the meter elements. Accordingly the up-keep expense and attention required should be less than with the older type of transmitting system. Life tests made in the laboratory indicate also that under normal operating conditions radio tubes as used in this application should have an average life of much more than a year. In addition to the distinct advantages already mentioned, the apparatus is more compact than the motor-operated device and the currents which contacts *K* are required to handle are greatly reduced being only from 40 to 80 microamperes.

Clinical Sunlight—

Natural and Artificial

DISCOVERY of reasons for the well-known beneficial effects of sunlight on health has been a stimulus to efforts to produce artificial sunshine for use when and where natural sunshine is not available. Knowledge of the amounts of energy in various wavelengths of the solar spectrum throughout

---

From an article written by A. O. Downes, National Carbon Co., for *Research Narratives*, Dec. 15, 1930, published by the Engineering Foundation, Inc., 29 West 39th Street, New York, N. Y.

the year is necessary for production of the best artificial sunlight. Therefore measurements of sunlight in summer, fall, and winter, have been made at two sanatoria, in Ohio and Colorado, where sunlight has been used for years in treating disease. The physicians in charge in Colorado have found that noon winter sunshine has given the best results.

There are indications that several more or less clearly defined bands of the spectrum produce certain biological effects. Most clearly defined is the so-called antirachitic region (limited to wave lengths less than 3,100 Angstrom units), which is included in that portion of sunlight entirely removed by ordinary window glass. (The Angstrom unit is equal to a ten-millionth of a millimeter.) This band is responsible also for sunburn. The band of very short ultra violet (not present in sunlight) below about 2,800 Angstrom units is destructive to bacteria and molds. There are other bands which have specific biological effects but the evidence is not so complete as yet as for the two bands mentioned.

Carbon arcs have been produced closely approximating the amount of sunlight in more or less narrow bands at definite distances from the source, and some of these carbon arcs have been in use for the treatment of disease ever since Finsen began using the carbon arc at Copenhagen about 1895. Finsen's work has been continued by physicians all over the world using various types of carbon arc as well as other sources of light.

The carbon arc has been a useful tool to these investigators as, by the use of various metals and chemical compounds in the carbons, the quality of the light produced can be varied through a wide range. If light rich in the far ultra-violet entirely absent in sunlight as it reaches the earth is desired, the carbons are cored with iron or a combination of several metals such as iron, nickel, and aluminum. Carbons containing silver have been used to produce a strong band in the ultraviolet just above the so-called antirachitic band (2,900 to 3,100 Angstrom units).

Ideal artificial sunshine should have only the wavelengths present in natural light and in exactly the same proportions. At present no artificial illuminant has been produced which exactly duplicates sunlight in the distribution of energy in the various wavelengths, but a light which closely approaches sunlight in quality is given by an arc burning carbons cored or impregnated with salts of the rare earths. There are several chemical elements in these rare earths, but their effect on the light from the carbon arc is due principally to the metal, cerium.

An important property of any carbon arc is that the light emitted is dependent only upon the grade of carbon—that is, the kind and quantity of chemical elements used in the cores—and the current and voltage at which the arc is burned. The quality of the light therefore is independent of the lamp mechanism, but the quantity and direction of the light depend very greatly upon the efficiency of the reflectors and other features of design.

Coordination—The Essence of Modern Engineering

By
WILLIAM S. LEE President A. I. E. E.

ENGINEERING ENTERPRISE has developed so rapidly from the application of individual technical skill to the combined technical efforts of many and variously qualified persons, that it seems propitious to consider briefly one of the most important of the present controlling features. A modern engineering undertaking of any appreciable size whatever involves influencing factors ranging all the way from the purely political to the purely economic; from the purely theoretical to the most simple and practical. Each of these factors of necessity must contribute its share to the ultimate design or structure, each to be interpreted and applied by a skilled technologist. Thus it is that coordination, hackneyed word though it be, comes to the fore as representing a function without which no engineering enterprise of any magnitude may hope to succeed in the full sense of that word.

Successful operation presupposes coordinated construction which in turn is dependent upon coordinated design, the whole enterprise resting fundamentally upon coordinated man power. The design of a modern complicated project represents the composite thought and combined experience of many minds so carefully blended, so well balanced, and so thoroughly interlocked, that each part will function and work in unison with every other part. Every project of any importance should be carefully designed in its entirety before very much if any of the construction work is undertaken. Only by this means may the construction engineer obtain the necessary insight into the ultimate purpose and use of the undertaking for which he is responsible, as well as the strength and character of each integral part, through which insight he may produce the desired results in the finished product. Only with a composite picture of the whole may the construction engineer proceed intelligently and meet modern economic limitations by building safely, quickly, and economically.

The achievement of a perfect structure in this day of broad and rigid requirements would be impossible without the assembled minds and the coordinated efforts of many kinds of engineers and technical specialists. In spite of this well-known fact, however, it is a common

---

An address delivered at the annual summer convention of the A. I. E. E., Asheville, N. C., June 22, 1931.

fallacy to look upon the result achieved as being the product of the efforts of one man. The really big man in engineering as well as in other professions is the simple man who readily recognizes and admits the fact that all major enterprises are fundamentally the products of well-directed group action. Very often the greatest and the most valuable man in a coordination conference is the man who can abandon his own ideas to espouse the cause of others in the interest of unified and effective effort.

In pausing for a moment to consider some practical examples we naturally turn to the field of electricity. One of the most perfectly coordinating forces in modern times is found in the transformation of energy into electric power and the application of this new form of energy into productive work. So perfect is the coordination that can be secured in the field of electricity that every phase of the almost innumerable detailed operations involved in a modern power plant may be so interlocked by electrical apparatus and so energized by electric power that they operate in perfect unison and always are ready with instantaneous response to the will of the operator in charge.

To cite another case of mechanical coordination, let us consider briefly the modern paper mill with which many of you are familiar. The real heart of this mill lies in the long line of rolls. These rolls are steam-heated and over them passes the paper as it evolves from a pulp to the finished product. Due to the fact that absolute uniformity of speed is required it was considered impossible until a few years ago to drive these rolls by any means other than spur gears. The electrical engineer, however, solved the situation by designing sensitive and accurate control equipment by means of which many electric motors may be electrically so interlocked as to maintain rigid synchronism. Thus these many independent motors turn the several rolls drawing the endless paper strips through them at a high speed, yet with a smoothness that avoids tearing even the most delicate paper.

As another example of coordinated effort consider the widely heralded Empire State Building in New York City. If prior to the completion of that structure you had visited the site and inspected the old building upon it, and had you been able to view the tremendous quantity of material of almost innumerable kinds that went into it, and then had been told just how long it would take to remove the old structures and assemble the raw materials into a new structure, you could have been pardoned for exhibiting grave doubt as to the possibility of accomplishing such a feat. Yet, as a result of strict coordination of design and construction, and the coordinated mobilization of the materials which had to be brought in piece by piece, that tremendous structure was completed within a phenomenally short time to its full height of 1,247 ft. above the sidewalk line.

The failure of the designing engineer or the construction engineer to coordinate their various related branches of engineering, construction, or specialization, can mean nothing but lost energy, lost time, and lost money in any great project.

In engineering, your mission, and mine, is far greater and more important then merely designing or constructing a great project. We must so synchronize the many kinds of engineering and the many kinds of materials involved that the finished product shall be perfect in its design, construction, and operation. In this connection it should be remembered specifically that the ultimate aim in every project is a perfect product rather than a perfect design. In the face of constantly increasing and ever more exacting demands in all kinds of engineering projects, we are training more engineers and more types of engineers year by year as specialists to refine and improve our general designs.

We must go further and maintain that initiative which builds the type of citizenship to which we owe our inventions, our developments, our progress—a citizenship far more valuable than the gold seams of arctic Alaska or the diamond fields of tropical South Africa—a citizenship that recognizes fully the fact that the only true equality in life is equality in opportunity.

In closing I wish to leave a message for the young engineer, and for the engineering student. It is my wish to impress these young men with the fact that opportunities still abound in the field of engineering in general, and electrical engineering in particular. True the specifications are somewhat broader and the requirements materially more rigid than they used to be; but to offset this, the young engineer of today has at his command a wealth of technological information nonexistent in earlier days. In my own opinion the wonderful field of coordination upon which I have touched but briefly now furnishes a new line of endeavor for you young engineers, and opens up a magnificent panorama of opportunity for service to yourselves and to your country.

If it were possible for Opportunity to stand before you today she doubtless would say:

"They do me wrong who say I come no more
When once I knock and fail to find you in;
For every day I stand outside your door,
And bid you wake, and rise to fight and win.

Wail not for precious chances passed away,
Weep not for golden ages on the wane;
Each night I burn the records of the day;
At sunrise every soul is born again.

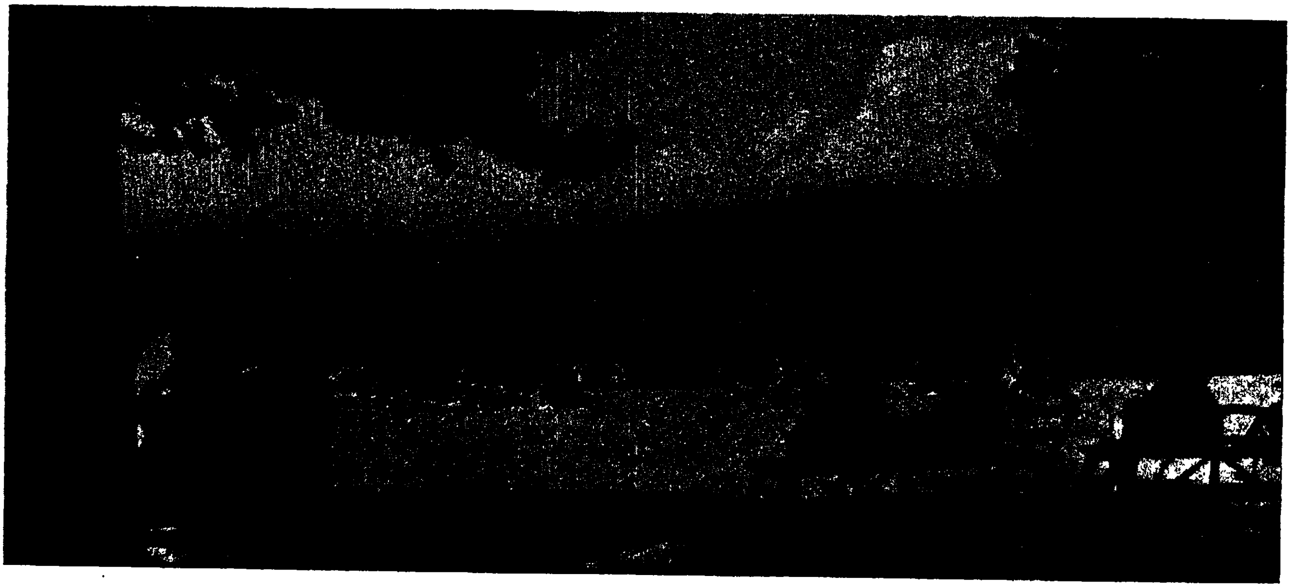
Laugh like a boy at splendors that have sped:
To vanished joys be blind and deaf and dumb;
My judgments seal the dead past with its dead,
But never bind a moment yet to come.

Though deep in mire wring not your hands and weep;
I lend my arm to all who say 'I can!'
No shamefaced outcast ever sank so deep.
But yet might rise again and be a man!

Dost thou behold thy lost youth all aghast?
Dost reel from righteous retribution's blow?
Then turn from blotted archives of the past
And find the future's pages white as snow.

Art thou a mourner? Rouse thee from thy spell!
Art thou a sinner? Sins may be forgiven;
Each morning gives thee wings to flee from hell;
Each night a star to guide thy feet to heaven."

News
Of Institute and Related Activities



Did you ever take a swim a mile up in the air? This is the famous mile-high beach at Lake Tahoe, California

Will You Take
"Your Vacation at the Lake Tahoe Convention"?

A TECHNICAL PROGRAM second to none, in which many essentials of present-day demands upon electrical engineering will be set forth and emphasized; a diversive program of which golfing, dancing, feasting, outdoor sports and a multiplicity of other delighting holiday occupations will be the happy ingredients—these are some of the things in store for those who will heed the call and follow the injunction to "Make your vacation include the Tahoe convention;" joys which shortly will be linked irrevocably with recollections of the Institute's twentieth Pacific Coast convention to be held August 25-28, 1931, now bearing high promise of being "the best one ever." And who will not enjoy the climax of Wednesday evening August 26, with a real barbecue followed by a general meeting and subsequent entertainment?

Technical Program

With L. F. Leurey (M'27) of San Francisco in the chair, the technical sessions will open with the presentation of three papers devoted to the profession in industrial application. The second session presided over by S. J. Lisberger (M'11) chief engineer in charge of the division of electric distribution and steam engineering, Pacific Gas & Electric Company, will offer an interesting and instructive collation of facts on a-c. networks, the Mokelumne River development (by Mr. Lisberger's own company), line control of interconnected networks, and "tuned" power lines. Wednesday, August 26, with C. E. Fleager (F'26 and vice-president) chairman, will be given over to a new and detailed study of the ever active subject, communication; on this occasion from both community and intercontinental standpoints. In the evening, convention guests will be afforded the pleasure of listening to C. E. Grunsky, internationally known president of the American Engineering Council, who will address the convention concerning "business and economics," a subject never more vital than at the present moment.

The technical program will come to

fitting close with Friday morning's session on electrophysics and general subjects including cathode drops in arcs and glow discharges, the kindling of electric spark-over, snow surveys, and radio coordination; R. W. Sorensen (F'19) professor of electrical engineering, California Institute of Technology, presiding.

ENTERTAINMENT

As earlier paragraphs suggest, an ample program of entertainment has been searched out and perfected by diligent local committees. In addition to diversions already named, there will be held on Friday evening "A Night at Monterey," a gala celebration modeled after the Spanish fiestas of old. Tahoe Tavern and Lake Tahoe on the shore of which it is located are unexcelled for pleasures and beauty of surroundings. Tennis, swimming, golf, horseback riding, and an exceptionally fine bowling alley all are available within the Tavern grounds, while the Kit Carson Trail to the historic mining cities of Carson and Virginia City in Nevada offers a short, but ultra scenic trip. The usual tournament for the Fisken Cup, Pacific Coast A. I. E. E. golf trophy, will be played on the Tahoe course. The majority of interesting points may be visited with ease and comfort in less than a day's time for the round trip.

The ladies have been specially planned for of course; a boat ride to Emerald Bay, bridge parties, and automobile trips have been carefully arranged for all those interested in their participation. On the evening of Thursday, August 27, a short playlet will be staged "to provide fun for all"?

The "Night in Monterey" will be held for the most part upon the delightful and well-equipped beach and boardwalk, ably engineered by the management of the Tavern.

VACATION SUGGESTIONS

In line with the promise of the convention's part in vacation plans it should be remembered that Lake Tahoe is in the very heart of California's famous Sierra Nevada mountain range. In almost every direction trips upon the lake offer an entry into splendid mountain scenery. Yosemite Valley, the historic Mother Lode gold mining country, Sequoia and General Grant National Parks, and other attractive spots are daily reached by good roads from the main highways in central and southern California. Members coming from or through Oregon and Washington will find Crater Lake, the Oregon Caves, and the Coast highway through the famous redwood belt delightful and recreative.

Attractive convention rates will be made available to members and guests at Tahoe Tavern for the entire week of August 23 to accommodate those wishing to devote a few uninterrupted days to pure diversion.

REGISTRATION AND HOTEL ACCOMMODATIONS

A general information and registration desk will open in the lobby of the Tavern Monday, August 24, and delegates and guests are requested to call there as soon after arrival as possible to obtain badges and news of convention schedule. The following fees covering registration, banquet, all scheduled events, and greens fees for the golf tournament will be in effect:

Members and men guests....	$5.00
Ladies.....................	3.00
Student members...........	1.00
Student guests..............	2.00

Tickets for the Thursday evening banquet are for only those registering for the convention; this applies to members, men and women guests, enrolled students and student guests. Tahoe Tavern is offering special convention rooming rates to Institute members and their families attending the convention. Many of the exceptionally large rooms are suitable for groups of four or five, and better to accommodate the unusual number of persons expected the management hopes that those who care to take advantage of this club arrangement will make up their own parties and thus simplify the question of hotel space allotment. Convention rates including meals will be as follows:

Room or small suite with bath (shared by 1, 2, or 3) per person per day............	$8.00
Room or suites with bath (shared by 4 or more) per day per person............	7.50
Room without bath, per person per day..............	7.00

All reservations must be made through the hotel committee by means of the regular hotel reservation blank provided; registrations made direct with the Tavern will not be recognized to benefit by convention rates. Order of receipt will establish precedence of choice of accommodations, etc.

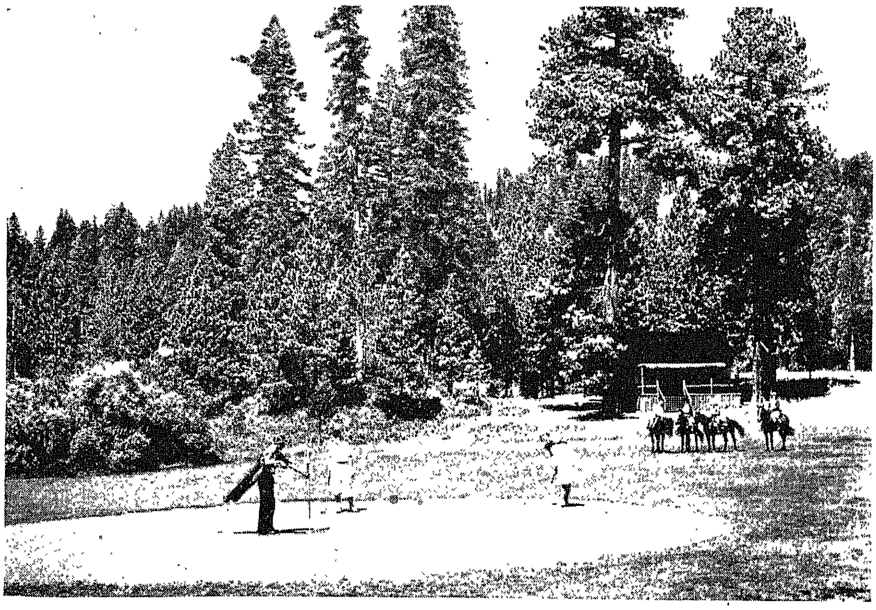
THE FISKEN TROPHY

The John B. Fisken Cup, much coveted golf trophy, is awarded annually to the best tournament score among members of the Pacific Coast Sections from 18-hole medal play at handicap. Many other prizes also will be awarded, all of which should make the tournament a feature attraction to any enthusiastic registered delegate or guest. No greens fees will be charged for the tournament, but specific information establishing handicap, etc., should be returned with the registration card.

TRANSPORTATION

Excursion rates are available from all points, railroad service to Lake Tahoe being provided by the Southern Pacific Company via its Overland Route. Spe-

Tahoe Tavern, headquarters of the forthcoming Pacific Coast convention



The annual tournament for the John Fisken cup will be played among the pines of the majestic "High Sierra"

cial routing information for making the trip by auto travel through most historic and scenic territory is made available by The Pacific Gas & Electric Company which will arrange to have its local representatives along all routes to the Lake to furnish specific information and render any possible service in case of emergency.

Committees

General convention committees and officers serving in the various departmental divisions of convention activities are as follows:

Chairman, A. W. Copley (F'26); vice-chairman, P. B. Garrett (M'30); both of Westinghouse Electric & Mfg. Company, 1 Montgomery Street, San Francisco, Calif.; secretary, E. F. Maryatt (M'27) of the Pacific Gas & Electric Company, 245 Market Street, San Francisco, Calif. Committee chairmen include A. G. Jones (A'07) *entertainment*; E. A. Crellin (F'28) *finances and hotel*; A. V. Thompson (A'23) *golf;* F. R. George (M'25) *inspection trips;* W. C. Heston (M'20) *publicity;* M. S. Barnes (A'18) *registration;* C. E. Fleager (F'26 and vice-president) *reception;* D. I. Cone (M'24) *technical program;* S. G. Palmer (A'15) *student activities;* P. Lebenbaum (M'13) *transportation;* and Mrs. Hector Keesling, *ladies' entertainment;* assisted by C. E. Carey (M'25), H. B. Carpenter (F'18 and vice-president), J. N. Chamberlain, L. B. Fuller (A'03), L. F. Fuller (F'23), A. V. Guillou (M'27), J. Hellenthal (M'23), H. W. Hitchcock (M'27), G. L. Hoard (A'19), A. H. Kruel, P. J. Ost (M'23), W. C. Smith (M'26), and L. A. Traub (A'28), members of the local committee.

Technical Program

Tuesday, August 25

10:00 a. m. Industrial Applications—L. F. Leurey, chairman.

Electrical Power in Wood Products Industry, by C. E. Carey and K. L. Howe, Westinghouse Electric & Mfg. Company, Seattle, Wash.

Application of Electricity to Oil Field Operation, by H. C. Hill and J. B. Selegue, Los Angeles

Correlation of Induction Motor Design Factors, by V. Hoover, Teaching Fellow in E. E., California Inst. of Tech.

2:00 p. m. Power Transmission and Distribution—S. J. Lisberger, chairman

Economics of A-C. Networks for Secondary Distribution, by S. B. Clark, Portland, Ore.

The Mokelumne River Development of the Pacific Gas & Electric Company, by E. A. Crellin, E. M. Wright, and B. D. Dexter, Pacific Gas & Elec. Company, San Francisco, Calif.

Tie-Line Control of Interconnected Networks, by C. A. Powel, Westinghouse Elec. & Mfg. Company, and T. E. Purcell, Duquesne Lt. & Power Company, Pittsburgh, Pa.

Tuned Power Lines, by H. H. Skilling, Stanford University

Wednesday, August 26

9:30 a. m. Student Technical Session No. 1

2:00 p. m. Communication—C. E. Fleager, chairman

Intercontinental Telephone Service, by J. J. Pilliod, engineer, American Tel. & Tel. Company, New York, N. Y.

Electrical Solutions of Problems of Regular Scheduled Flight, by C. F. Green, Schenectady, N. Y.

The San Francisco–Los Angeles Section of the Pacific Coast Telephone Cable Network, by E. M Calderwood, San Francisco, and D. F. Smith, Los Angeles, both of the Pacific Tel. & Tel. Company

Electrical Sound-Absorption Measurements, by A. L. Albert and W. R. Bullis, Corvallis, Ore.

Evening

Barbecue dinner

Address by C. E. Grunsky, president of American Engineering Council "Business Cycles and Some Economic Problems"

General meeting followed by entertainment

Thursday, August 27

8:00 a. m. Student Breakfast and Conference

Afternoon

Sports

Evening

Banquet and playlet

Friday, August 28

9:30 a. m. Electrophysics and General Subjects—R. W. Sorensen, chairman

Cathode Drop in Arcs and Glow Discharges, by S. S. Mackeown, California Institute of Technology, Pasadena, Calif.

The Kindling of Electric Sparkover, by C. E. Magnusson director of engineering experiment station, University of Washington, Seattle

Snow Surveys, by H. P. Boardman, professor of C. E., director of engineering experiment station, University of Nevada, Reno

Radio Coordination, by H. N. Kalb, Great Western Power Company, and C. C. Campbell, Pacific Gas & Electric Company, San Francisco

Irrigation Waste to Run Texas Plant

A hydroelectric plant to be built by the Central Power & Light Company near Eagle Pass, Texas, will utilize waters returned from the Maverick County Irrigation District No. 1, after they have been diverted for irrigation purposes and carried back by a supply canal to penstocks.

Excavations for the power house of this plant were started May 23, 1931; it is expected that the plant will be ready for operation early in 1932. The generators will be of 3,500 kw. 6.9 kv. umbrella type, the power produced to be transformed to the higher voltages in an adjacent substation. A 66-kv. line coming from the East supplies power for construction now and will be used later to carry power to the operating company's other points of distribution. During the irrigation season the river flow amounts to approximately 1,000 sec-ft. but at certain other seasons it reaches a 1,500 sec-ft. volume—*Wendell C. Fowler, San Antonio Section Correspondent.*

Asheville Convention Closes Busy Institute Year

WITH more than 500 persons in attendance the Asheville convention proved a fitting climax to a busy year. Essentially every District and active Section throughout the United States and Canada and including Mexico City, were represented It was of particular interest to note the high percentage of women guests who attended from distant points giving color and lending charm to an affair already under the spell of hospitality so typical of the Old South.

IMPORTANCE OF DISTRICT MEETINGS STRESSED

In a prelude to his final formal address before the Institute President Lee emphasized again his fervent wish to "Take the Institute to the members instead of trying to bring the members to the Institute." In this connection he emphasized the increasing value of District meetings, urged every effort to develop them, and outlined current progress in that direction. President Lee also called attention to the great value of the younger members to the Institute and of the Institute to the young electrical engineer, urging a greater participation on the part of the younger men. In his formal address, full text of which appears elsewhere in this issue, he sounded a challenge and a distinct note of encouragement to engineering students.

DELEGATES SESSIONS WELL ATTENDED

Two particularly well attended sessions of delegates, officers, and members were held at which several subjects of particular import to Institute members were rather fully discussed. These included the licensing of engineers, membership problems including transfer qualifications, and Section and student Branch operating problems. More concerning all of these subjects will be presented in ELECTRICAL ENGINEERING as the various committee studies and reports are completed. Technical sessions all were very well attended, attendance being enhanced perhaps by the fact that many of the sessions were held on the open verandas of the Grove Park Inn overlooking the North Carolina mountain scenery. A brief outline of the several papers presented is given in the paragraphs that follow; discussion will be reviewed in a subsequent issue.

Interconnections Discussed and Evaluated

RECOGNITION of some of the technical problems involved in the present-day trend toward mergers and large cooperative undertakings in the field of the electric service company, an entire session of the Asheville summer convention was devoted to a symposium of four papers on this general subject.

In his paper relating to the classification and evaluation of interconnection services A. E. Bauhan (M'17) of the Public Service Electric & Gas Company, Newark, N. J., defined his interpretation of the word *interconnection* as meaning the physical tying together of two or more independently owned or separately managed electric systems for the purpose of realizing financial benefit or service improvement through the interchange of power.

Under the heading of service classification the author listed emergency service, load diversity, firm power, storage power, intra-company use, economy flow, and unintentional flow. He expressed the hope that these seven suggested classifications would form the basis of discussion and experiment which would lead eventually to a generally acceptable classification and nomenclature.

ECONOMIC EVALUATION

After defining and describing these classifications in some detail, Mr. Bauhan launched into a discussion of interconnection service evaluation, stating that such evaluation represented the economic basis upon which the desirability of a proposed interconnection should be made. He stated that the services previously mentioned may be evaluated as to capital cost by determining the aggregate saving in the cost of generating capacity, and then comparing the result with the capital cost of the interconnection itself.

Stating that "interconnection is only one of the many factors contributing to the accomplishment of the purpose of the electric utility industry," G. M. Keenan (F'29) superintendent of the Penn-New Jersey Interconnection (Hazleton, Pa.) pointed out that the "possibilities of interconnection can be realized only when the system is effectively developed and operated."

DIVERSE INTERESTS OF PARTICIPANTS MUST BE COORDINATED

Mr. Keenan emphasized the limiting feature represented by the fact that while interconnected systems operate as a unit, the companies owning them have diverse interests which must be sufficiently coordinated to make available to all participants the maximum benefits to be realized by interconnection. Mr. Keenan stated also that interconnection development usually tends to reduce generating costs at the expense of increased transmission costs and hazards, concluding that "possibly there are some limits to the size of the interconnected system and the degree of coordination desirable between ownership."

The interconnected system representing ten independent operating companies of western Pennsylvania, eastern Ohio, West Virginia, and Maryland, were described at some length by H. S. Fitch (A'18) of the West Penn Power Company, Pittsburgh, whose paper reflected the operating practise and experiences of that group. He described the territory served by these companies and outlined the benefits derived by the interconnection as including a reduction in spare capacity, investment and operating economies effected through (1) dovetailing of construction programs; (2) joint financing of power stations and transmission lines; and (3) noteworthy protection of service continuity.

DISADVANTAGES MORE THAN OFFSET BY BENEFITS DERIVED

E. W. Dillard (M'30) and W. R. Bell (A'15) of the New England Power Engineering & Service Corporation, Boston, Mass., described in some detail the various practical problems involved in a typical New England interconnection involving systems in parts of six states. After outlining the history and development of the various interconnections, the authors gave as the objectives of their system the following:

1. The absorption of surplus hydro power from systems generating largely from unregulated hydro sources.
2. The absorption of large quantities of surplus steam with resultant good load factor on relatively high-grade steam plants of adjacent systems.
3. Arrangements for the purchase of surplus steam capacity in various stations which resulted in a certain amount of firm capacity.
4. The sale or purchase of firm power.

The authors outlined in some detail the benefits derived from these various factors, described the contractural relations entered into in the various cases, and pointed out certain disadvantages and difficulties encountered. They stated definitely, however, that they "do not believe that any disadvantages have come about in any New England interconnection that are not offset entirely by benefits derived."

Transients Important in Electrical Machine Design

ELECTRICAL machinery and its design and operating characteristics, always of interest in Institute conventions, were no exception at Asheville. This time the subject of electrical transients seemed to dominate in all presentations and discussions.

The problem of reestablishing excitation of a loaded alternator operating in parallel with others was discussed at some length by D. D. Higgins (M'27) and E. Wild (A'27), both of the Commonwealth Edison Company, Chicago. The authors described tests performed with large turbine-generators operating under load, and gave a résumé of various answers to a questionnaire bearing upon the phenomena accompanying the interruption and reestablishment of a generator's d-c. excitation. As a result of their investigation the authors conclude that the reexcitation of a generator without removing it from the bus is a justifiable and safe operating procedure and one which will restore all conditions to normal in the shortest time.

REACTANCE AND TIME CONSTANTS CALCULATED

L. A. Kilgore (A'29) of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., presented a highly mathematical dissertation pertaining to a method of calculating reactance constants and time constants, as they affect transient characteristics of synchronous machines. The author pointed out that recent theoretical advances have introduced many new constants; also that most of the discussions on such constants published previously have been concerned with the *application* rather than the *calculation* of the values involved. In his paper Mr. Kilgore calculated the more significant constants and gave comparisons between tests and calculated values to support the accuracy of his method. In two extended appendices he gave formulas for salient-pole machines and turbine-generators, and pointed out that because of differences in construction many of the formulas for turbine-generators are different from those for salient-pole machines. He discussed the more important differences.

As a companion paper to Mr. Kilgore's, S. H. Wright (A'29) also of the Westinghouse Company presented an extensive treatise descriptive of the determination by test of synchronous machine reactances, resistances and time constants. The author emphasized the practical side of the situation basing his statements and conclusions upon observations made from many tests and their results. Mr. Wright considered three classes of synchronous machines—turbine-generators, salient-pole machines with dampers, and salient-pole machines without dampers. In his tests the author achieved saturation effect under short circuits by applying short circuits to machines operating at rated voltage. He discussed in some detail the more important of the variable saturation effects, and by defining certain saturation and other values attempted to provide a definite basis for the practical specification of machine constants.

TRANSFORMER TRANSIENTS AFFECTED BY MANY FACTORS

An essentially mathematical study of transient voltages in transformers and similar equipment was presented by L. V. Bewley (A'27) of the General Electric Company, Pittsfield, Mass. Mr. Bewley devoted his major effort to showing the effects on voltage distributions of wave shape, circuit constants, and neutral impedances, and in describing methods by which the voltage distributions may be controlled or varied. He derived a general differential equation for a circuit consisting of distributed self- and mutual-inductance, series and shunt capacitance, series resistance and conductance along the stack to ground. The author presented (1) numerous solutions of his equation covering various sets of conditions; (2) equations corresponding to many different applied waves showing the effects of wavelengths, wave front, etc.; (3) equations for calculation of potential difference or voltage gradient between points in windings; and (4) tables showing the influence of various circuit constants on wave characteristics.

In describing field transients in magnetic systems, Ernst Weber (A'31) of the Brooklyn (N. Y.) Polytechnic Institute gave a comprehensive mathematical solution of the situation arising from the sudden application of a d-c. voltage through an electromagnetic circuit containing a partly laminated and partly solid iron core with an air gap. Ranging in mathematical manipulations from Maxwell's field equations for eddy currents and magnetic field in an iron core to Heaviside's operational calculus, the author achieved results which he expressed by means of a time constant of the magnetic field. In discussing the practical application of his results the author gave a numerical example and called attention to the effectiveness of quick response excitation for improving electric system stability under short circuit conditions, particularly where large synchronous generators are involved.

Efficient Communication Facilities Required for Successful Operation

REFLECTING the important position occupied by communication facilities in the successful operation of a modern electric light and power system, a symposium of five papers dealing with important phases of the subject occupied one entire technical session of the Asheville convention. Nine different authors collaborated in the preparation of these papers representing some five different power systems and three different divisions of the Bell Telephone System.

In practically all cases the three major divisions of communication service that received specific attention were those pertaining to (1) operating activities including dispatching, plant and substation operation, line patrol and repairs; (2) customer service activities including new installations, disconnections, transfers and service complaints; and (3) administrative activities including executive, sales, and business functions as differentiated from the service functions.

PRINCIPAL REQUIREMENTS OUTLINED

Fundamental considerations underlying the planning and providing of adequate and economical communication services for electric utilities were rather fully outlined and briefly discussed in a paper prepared by R. N. Conwell (F'31) of the Public Service Electric & Gas Company, Newark, N. J., G. M. Keenan (F'31) superintendent of the Penn-New Jersey Interconnection, Hazleton, Pa., C. F. Craig (M'27), special representative of the American Telephone & Telegraph Company, New York, and E. C. Briggs of the Ohio Bell Telephone Company, Cleveland. These authors described the normal workings of an electric utility as being so divided that all three classes of communication service mentioned in the preceding paragraphs are required. In enlarging upon the subject of communication facilities for operating activities, they stated that such facilities needed to be:

1. Easy to operate and capable of establishing prompt communication connection.
2. Available at times when generating and distribution facilities are in trouble.
3. Of sufficiently good quality to avoid misunderstandings and to permit conversations to be carried on with ease.
4. Adequately protected from the safety standpoint but not to a degree that would interfere with communication service during electric service difficulties.
5. Of sufficient capacity to obviate serious delay even under emergency conditions.

Leased Lines Preferred to Carrier Systems

E. S. Bundy (M'30) of the Buffalo (N. Y.) Niagara & Eastern Power Corporation, described the communication facilities of the western division of the Niagara-Hudson system. He characterized the modern tendency of interconnecting electric generating and transmission systems as leading to systems covering "such large areas that the communication lines have become almost as important as the power lines themselves."

Mr. Bundy described the communication requirements of his system which include remote metering, system dispatching, load supervision, commercial business, and ordinary interdepartmental communication. Perhaps the most important communication service in that system is provided by lines leased from the telephone company, arranged in some cases so that conferences involving several persons may be held over the lines. Single-frequency duplex carrier-current installations providing two-way communication between eight of the more important stations on the consolidated system supplement the line service. Under normal operating conditions leased lines are used in preference to the carrier system because of the better quality of transmission.

A description of the communication needs of a power company serving a large metropolitan area was given by P. B. Juhnke (M'20) of the Commonwealth Edison Company, Chicago. Detailed information pertaining to load dispatching problems on his system were discussed, and the use of remote metering facilities as an effective aid in conducting load dispatching operations was described. On this system the technical group in the load dispatching office is in direct private wire communication with all generating and distribution stations, and with most substations. In describing his remote metering system Mr. Juhnke mentioned that metallic telephone circuits now are used exclusively but stated that since telemetering impulses now can be transmitted over carrier-current communication systems, the usefulness of such carrier systems has been enhanced materially.

Coordinated Systems most Economical

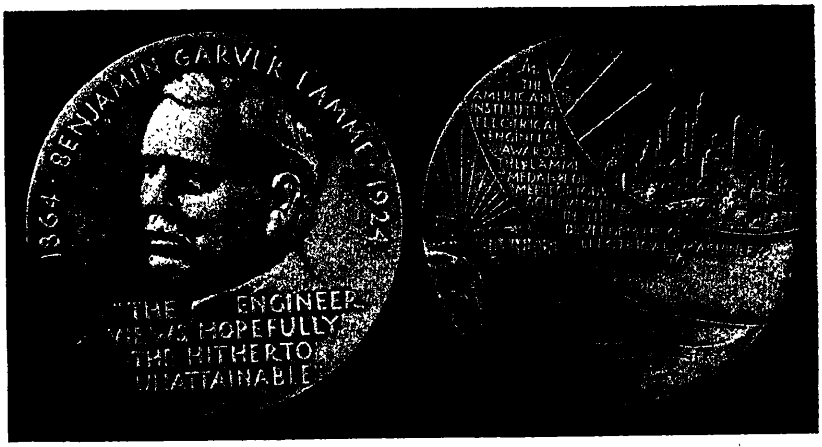
C. A. Booker of the New England Power Association, Boston, and M. E. Clark of the New England Telephone & Telegraph Company, Boston, described at some length a cooperative study of power system communication conducted jointly in New England by the power company and the telephone company. The problems there encountered involved a survey of existing communication facilities in the several districts effected, the determination of present and future communication requirements, and the analysis of these requirements to ascertain what improvements, changes, or additions should be made. Coordination of existing facilities both on the Bell system and on the Power Association's various private lines was the watchword of the joint investigation.

Switching from the communication problem of the relatively closely knit interconnected system to that of the relatively far flung interconnected system, E. C. Stewart of the Arkansas Power & Light Company, Pine Bluff, Ark., described the communication system in use on the Arkansas - Louisiana - Mississippi Interconnected Power System. Long distances between stations are the regular order of affairs on that system, and as a result carrier-current telephone equipment is used to a large extent, the longest distance so served being 459 mi.

After outlining the history of development and describing the problems incident to the development of the carrier-

---

"The Engineer Views Hopefully the Hitherto Unattainable"


BENJAMIN GARVER LAMME
1864-1924
"THE ENGINEER VIEWS HOPEFULLY THE HITHERTO UNATTAINABLE"
THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AWARDS THE LAMME MEDAL

SUCH is the message of the Lamme Medal established by a bequest of Benjamin Garver Lamme, chief engineer of Westinghouse Electric & Manufacturing Company, who passed away July 8, 1924, after a life of professional usefulness. According to provisions of the bequest, a gold medal accompanied by a replica in bronze goes in award each year to a member of the Institute "who has shown meritorious achievement in the development of electrical apparatus or machinery." William J. Foster, D. Sc., consulting engineer (retired) of the General Electric Company, Schenectady, N. Y. was this year's recipient (see p. 230, Electrical Engineering, March 1931). A similar bequest was made by Mr. Lamme to Ohio State University, by which annual award is made to a graduate from any of its engineering branches "for meritorious achievement in engineering or the technical arts;" while a third medal is awarded by the Society for the Promotion of Engineering Education "for accomplishment in technical teaching or actual advancement of the art of technical training." The first Lamme Medal to be awarded by the Institute (1928) was given to Allen B. Field (F'13) consulting engineer, Manchester, England; the second to Rudolph E. Hellmund (F'13) chief electrical engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. C. E. Skinner, assistant director of Engineering, Westinghouse, received this year's award from Ohio State. (See p. 519 of this issue.)

current system, the author related some operating experiences. He said "the carrier-current installation on the interconnected system, supplemented by the use of toll service, and one or two leased or specially arranged circuits, is primarily for use by the dispatcher, but considerable business traffic is handled by the dispatching force outside of any rush period."

Automatic Control is Proving its Merit

CONCERNED with the general subject of automatic equipment five papers were presented at an Asheville session. Two of these dealt with the details of supervisory systems for electric power apparatus, one dealt with automatic combustion control, and two presented rather comprehensive outlines of actual operating experience with automatic and supervisory control equipment.

R. M. Stanley (F'23) of the Byllesby Engineering & Management Corporation, Chicago, Ill., described briefly the miniature switchboard supervisory automatic control equipment installed at the Ohio Falls Hydroelectric Station at Louisville, Ky., and gave a résumé of three years' operating experience with that equipment. Mr. Stanley gave the engineering reasons for the adoption of miniature supervisory switchboard and automatic control as being a desired reduction in capital expenditure, and reduced fixed and operating charges. As a result of his experiences he has concluded that automatic devices greatly enhance the services of a capable operator, and produce better station operation than would be possible by manual system of control alone.

Inspection and Maintenance Important Items

In a jointly prepared paper Garland Stamper (A'25) of the Columbia Engineering & Management Corporation, Cincinnati, Ohio, and F. F. Ambuhl (M'26) of the Toronto Hydro-Electric System, Toronto, Ont., Canada, described their respective operating experiences with automatic station and supervisory equipment. Mr. Stamper stated that the Columbia system has had automatic and semi-automatic stations of various types in operation for the past ten years, and as a result of experience stated emphatically that the degree of satisfaction secured in the operation of any type of automatic equipment is directly dependent upon the quality of inspection and maintenance.

Mr. Ambuhl reported that on the Toronto system automatic controls have given fairly satisfactory results and the supervisory controls have given excellent results, especially the cable-type supervisory." Relay failures constitute the chief source of trouble mentioned.

An a-c. supervisory control system devised to accomplish all that the more common d-c. supervisory systems now do, was described by O. K. Marti (M'27) of the American Brown Boveri Company, Inc., Camden, N. J. The equipment was said to be independent of interruptions in the a-c. supply at stations where it was installed, since it depends upon a small motor-generator set driven from the station battery. For this system five wires between stations are required, two being common supply lines, one a synchronizing wire, one a control wire, and one an indication wire.

Centralized Control Important in Railway Electrification

The Pennsylvania Railroad in its electrification in and around Philadelphia has made use of two installations of supervisory control for the remote operation of high-voltage a-c. step-down substations supplying energy to its traction system. The equipment used and the system involved were described by C. P. West (M'28) of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, and H. C. Griffith of the Pennsylvania Railroad Company, Philadelphia, who stated that the normal practise of the railroad has been to install substation control in signal towers adjacent to substation location, because most substations have been near 24-hr. signal towers. Conditions are changing, however, and the system is expanding beyond the normal operating radius of signal towers. The authors state that from the many advantages of centralized control, this method is destined to play an increasingly important part in future railroad electrification.

Automatic Systems for Accurate Combustion Control

Since heat-power plants have increased so enormously in size, and combustion practise reduced so nearly to an exact science, automatic combustion control has become an economic necessity according to C. H. Sanderson (F'18) and E. B. Ricketts of the New York Edison Company, who presented a joint paper describing several of the more important automatic combustion control systems. The authors cited as being among the important advantages: (1) the uniform loading of all boiler units; (2) instant response to changes in load; (3) correct proportion of fuel and air supply at all times; and (4) a ready means of providing for safety in operation through sequence interlocking of auxiliary equipment.

High-Voltage Cable Practise Continues to Advance

IN an Asheville session devoted exclusively to the subject of cables, the discussions presented ranged all the way from the most highly theoretical to the most practical. Three research workers, four manufacturers, and one prominent operating man presented papers representing their various fields of interest and thus contributed to a better general understanding of the subject.

Results of still further study on the open question hinging on the influence of residual air upon cable insulation life, were presented in a paper by J. B. Whitehead (F'12) and F. Hamburger, Jr. (A'26) of Johns Hopkins University, Baltimore, Md.,—their third A. I. E. E. paper on that subject. As a result of their intensive investigation, the authors have concluded among other things that:

1. The life of impregnated paper insulation increases steadily with a decrease in the amount of residual air.

2. For impregnating pressures above 2.5 cm. the life decreases rapidly with increasing pressure of impregnation. For pressures below 2.5 cm. the results show an increase of life of from 10 to 50 per cent between 2.5 cm. and 2 mm. impregnating pressure.

3. For impregnating pressures below 2.5 cm., normal variations in material and structure, particularly in the tightness of the structure, may offset the increased life due to decreasing the pressure of impregnation.

4. Cable compound deteriorates if it contains only a small amount of air even though kept in sealed containers, at room temperature. To avoid deterioration air should be entirely excluded.

5. Flat power-factor voltage curves and the absolute value of power factor should not be accepted as indications of long life.

6. Power-factor rise due to the initial application of voltage during a life test is indicated as a possible criterion of insulation life.

7. A very satisfactory type of sample and a reenforced end for accelerated life tests have been developed.

8. Narrow variations in the quality of both paper and oil may cause wide differences in the electrical characteristics and in the lives of the impregnated products.

INSULATION VARIABILITY LIMITS ALLOWABLE OPERATING STRESSES

M. C. Holmes (A'26) of West Virginia University, Morgantown, presented a paper describing a method of analyzing the effect of insulation variability in the determination of breakdown voltages and allowable operating stresses. He emphasized the necessity of considering the variability as well as the so-called strength of insulation and quoted terms of allowable operating stresses and failures in support of his contentions. He developed and discussed the application of a general equation, giving in terms of two parameters the breakdown voltage and the number of failures to be expected, the mean breakdown voltage, and the variability of insulation.

Oil-filled cables and accessories were described by R. W. Atkinson (F'28) and D. M. Simmons (F'28) of the General Cable Corp., New York, N. Y., who defined the term "oil-filled" as being ordinarily understood to indicate a cable in which the compound is of such viscosity as to be fluid at all operating temperatures.

General theory and some of the outstanding characteristics of oil-filled cable practise were discussed in some detail by G. B. Shanklin (M'29) and F. H. Buller (M'29) of the General Electric Company, Schenectady, N. Y.

BETTER CABLES AT LOWER COSTS PREDICTED

An illuminating and fairly comprehensive outline of economic high-voltage cable practise based upon extensive research and intensive practical application was given by D. W. Roper (F'14) of the Commonwealth Edison Company, Chicago. In illustrating the salient points of his discussion Mr. Roper presented numerous data and diagrams. He called upon utility companies to improve their standards of design and workmanship to keep pace with cable improvements effected by manufacturers. He stated definitely that in his opinion the present rate of improvement in the art of high-voltage cable practise would continue in succeeding years, and further in prediction said that:

1. Cables of all types and voltages will be operated at maximum temperature of from 85 to 90 deg. cent. without fear of deterioration.

2. Extensive oil reservoirs and accessories on oil-filled cable will be eliminated.

3. An installation of oil-filled cable will be no more complicated than a present day installation of ordinary cable.

4. Cable of subnormal quality will be eliminated by factory tests.

5. Initial costs per kva. of 66-kv. cable completely installed will range from 30 to 40 per cent lower than the present cost of ordinary cable.

6. Cable failures due to all causes will not exceed one per 100 mi. per year.

Standardization of Units an International Problem

ELECTRICAL units, their modernization, international standardization, precise determination, and proper application is a subject occupying a great deal of the time of many learned technologists throughout the world. Advancement in the art and science of electrical engineering has given rise to a rather concerted study of electrical units along the lines as just indicated, to say nothing of international effort to arrive at a logical and representative nomenclature. Reflecting the importance and timeliness of the subject, the fourth session of the Asheville convention was devoted to a symposium of four papers on various phases of the subject.

H. B. Brooks (F'31) of the Bureau of Standards, Washington, D. C., treated at some length the unit of electrical resistance, going into its past history, and outlining impending changes. The author described the mercury ohm as having been so long legalized as a material standard of resistance that it is regarded widely as a permanent institution of relatively precise proportions, but stated that practically it is obsolescent because of the technical difficulties attending its use. The author further characterized the mercury ohm as a necessary but expensive evil holding its place because formerly it could be reproduced more precisely than could the agreement between the results of absolute determinations of the ohm. He concluded his presentation saying that the technique of absolute determination has improved until now it may be said to be at least on a par with the mercury ohm as to reproducibility. Consequently this method should be used to obviate the laborious and time-consuming effort of high grade men now going into repetitions of mercury ohm determinations.

STANDARDS MUST KEEP PACE WITH ADVANCES IN EQUIPMENT

In a discussion of electrical units and their application, L. T. Robinson (F'12) of the General Electric Company, Schenectady, N. Y., emphasized the necessity of providing for the advancement of precise definitions and precision standards to keep pace with contemporary advances in equipment. In speaking of the importance of accurate measurements as far as scientific advance is concerned, he said "progress and improvement are made possible only to the extent that those interested in and working along the line of developing and improving measuring methods and instruments are able to anticipate the needs of those interested in the development and operation of systems, devices, and apparatus."

Pertaining to the international standard of electromotive force, and its low-temperature coefficient form, Marion Eppley (M'31) of the Eppley Research Laboratory, Newport, R. I., described at some length the great difficulty in achieving the physical conditions prescribed in the officially agreed upon fundamental definitions of certain electrical units. He described briefly several different types of so-called standard cells for reproducing physically a standard volt, discussing also various tests made on and the characteristics of the cells. He concluded definitely that his fifteen years of work on the cadmium cell have given him "ever increasing confidence in its reliability," even if it "is by no means foolproof."

LABORATORY POTENTIOMETERS DISCUSSED IN DETAIL

Information pertaining to the design of d-c. laboratory type of potentiometers was given by I. M. Stein (M'27) of the Leeds & Northrup Company, Philadelphia. The author treated his subject under the following ten headings: (1) early history; (2) factors affecting voltage range; (3) factors affecting potentiometer resistance; (4) low-voltage potentiometers; (5) analysis of potentiometer errors; (6) self-checking features of potentiometers; (7) galvanometer considerations; (8) comments on volt-boxes; (9) deflection potentiometers; (10) the potentiometer in industry.

Research Problems Vie with Cooperative Education

COOPERATIVE educational methods competed with transmission stability research problems for the attention of those attending the closing session of the summer convention.

D. C. Jackson, Jr. (F'30) of the University of Kansas, discussed in some detail the application of the cooperative method of instruction to engineering schools and polytechnic institutes. As constituting five important factors governing the application of the cooperative method to any given institution, the author considered (1) the size, (2) geographical location, (3) type of location, (4) method of support, and (5) organization of the institution. He discussed various methods of applying the cooperative plan and expressed the opinion that "no exact conclusion can be drawn concerning the general principles governing the installation of the cooperative method at an institution since the controlling conditions are so different in each case."

FACTORS AFFECTING THE EXTINCTION OF SHORT A-C. ARCS

The results of a study concerning the extinction of short a-c. arcs were discussed in a paper by T. E. Browne, Jr. of the Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa. Mr. Browne's findings as stated were:

1. That the arc space recovers the ability to withstand 100 volts or more within a few microseconds after a current zero, as predicted by Slepian's theory.
2. That the maximum allowable rate of voltage rise across the arc space which will just permit arc extinction, is much greater for very short arcs (1 cm. or less) than for longer arcs.
3. That the critical rate of voltage rise depends upon the electrode material and tends to vary as a decreasing linear function of the boiling point of that material.
4. That the higher-current arcs have a much lower critical rate of rise of voltage than the lower-current arc.

VACUUM TUBES SCORE AGAIN

A corona-tube voltage regulator designed to accomplish all of the functions of the ordinary vibrating type of regulator, and without the mechanical difficulties incident to the latter, was described by H. W. Dodge of the New Jersey Bell Telephone Company, and C. H. Willis (M'28) of Princeton University. The authors presented and described a circuit wherein a corona tube is used to regulate the output of a full-wave rectifier, the rectifier in turn controlling the excitation of a generator to give constant voltage. They presented very attractive performance curves covering the application of the apparatus to a 5-kva. generator under varying load conditions. The authors characterized the regulator as employing the same methods of compounding and line-drop compensation now in use and expressed the belief that the simplicity, compactness, high sensitivity, and quick response of the regulator offered important advantages.

LIGHTNING SURGES CAUSE ARCING FAULTS

Experimental studies of arcing faults imposed on a typical 75-kv. transmission system were discussed in a paper prepared jointly by J. R. Eaton (A'27) of the Consumers Power Company, Jackson, Mich., J. K. Peck (A'27) of the National Electric Light Association, New York, and J. M. Dunham (A'31) of the American Telephone and Telegraph Company, New York. High-voltage impulses simulating lightning were imposed upon an energized transmission line to cause flashovers. As a result of their observations the authors concluded that the probability of a lightning flashover causing a power arc is increased when power current is flowing past the flashover point, when the normal frequency voltage is increased, or when the normal insulation is decreased.

Effective arc resistance was described as being approximated by the ratio of the peak voltage to the peak current, the apparent power factor of the arc current and voltage being practically unity in most cases. The tests showed that arcs formed in a capacitive circuit are more persistent than those in inductive or resistive circuits, and indicated an average peak of about 300 volts per foot of arc length, for currents of about 100 amperes or more. Regarding system overvoltages arising from arcing grounds, the authors concluded the maximum to be approximately three times normal peak voltage from line to ground, and that it occurs on a sound phase and most frequently during the first cycle of the fault.

Minutes of Annual Meeting Held at Asheville June 22

The annual meeting of the American Institute of Electrical Engineers was held at the Grove Park Inn, Asheville, N. C., as the opening session of the annual summer convention, Monday morning, June 22, 1931. President W. S. Lee presided.

The annual report of the board of directors was presented in abstract by F. L. Hutchinson, national secretary. Printed copies were distributed to members in attendance and are available to any member upon application to Institute headquarters, New York. The report, which constitutes a résumé of the activities of the Institute during the fiscal year ending April 30, 1931, shows a total membership on that date of 18,334. In addition to the three national conventions and five District meetings, 1,628 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States, Canada, and Mexico. The report will appear in full in the Quarterly TRANSACTIONS of the Institute.

The report of the committee of tellers on the election of officers of the Institute was presented, and in accordance therewith President Lee declared the election of the following members, taking office August 1, 1931:

President:

C. E. Skinner (F'12), assistant director of engineering, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Vice-Presidents:

W. B. Kouwenhoven (M'22), professor of electrical engineering, assistant dean of the Engineering School, Johns Hopkins University, Baltimore, Md.

W. E. Freeman (M'27), head, department of electrical engineering, assistant dean of College of Engineering, University of Kentucky, Lexington, Ky.

Paul H. Patton (M'25), telephone engineer, Northwestern Bell Telephone Company, Omaha, Neb.

A. W. Copley (F'26), engineering manager, Pacific Coast district, Westinghouse Electric & Mfg. Company, San Francisco, Calif.

L. B. Chubbuck (M'26), switching equipment engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ont.

Directors:

L. W. Chubb (F'21), director of Westinghouse Research Laboratories, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

B. D. Hull (M'26), engineer, Southwestern Bell Telephone Company, Dallas, Tex.

H. R. Woodrow (F'23), electrical engineer, Brooklyn Edison Company, Inc., Brooklyn, N. Y.

National Treasurer:

W. I. Slichter (F'12 and national treasurer), professor of electrical engineering, Columbia University, New York, N. Y.

(These officers, together with the following hold-over officers, will constitute the board of directors for the next administrative year, beginning August 1: W. S. Lee (retiring president), Charlotte, N. C.; Harold B. Smith (F'13 and past-president), Princeton, Mass.; H. V. Carpenter (F'18 and vice-president), Pullman, Wash.; G. C. Shaad (F'13 and vice-president), Lawrence, Kans.; I. E. Moultrop (F'29 and vice-president), Boston, Mass.; H. P. Charlesworth (F'28 and vice-president), New York, N. Y.; T. N. Lacy (M'24 and vice-president), Detroit, Mich.; J. Allen Johnson (F'27), Buffalo, N. Y.; A. M. MacCutcheon (F'26), Cleveland, Ohio; A. E. Bettis (F'26), Kansas City, Mo. (terms expire July 31, 1932); J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. (terms expire July 31, 1933); A. B. Cooper (M'16), Toronto, Ont.; A. E. Knowlton (F'30) and R. H. Tapscott (F'29), New York, N. Y. (terms expire July 31, 1934).

President Lee then congratulated President-elect Skinner (F'12) upon his election and presented him with the president's badge. Mr. Skinner responded with a brief address, which was enthusiastically received.

The report of the committee on award of Institute prizes, as published in the June 1931 issue of Electrical Engineering (p. 448) was read by A. E. Knowlton, chairman of the committee of award, after which the prizes were presented by President Lee.

The Lamme medal for 1930, which, as announced in the March 1931 issue of Electrical Engineering (p. 230), had been awarded to W. J. Foster (F'16), of Schenectady, N. Y., was presented.

The annual presidential address was then delivered by President Lee, the subject being "Coordination—the Essence of Modern Engineering." (This address is published in full on p. 512 of this issue.)

Adjourned.

(Signed) F. L. Hutchinson,
National Secretary

"Who's Who in Engineering"

Engineers listed in the forthcoming edition of "Who's Who in Engineering" shortly will receive notification of the page upon which their listing occurs.

The publishers emphasize the fact that volumes of this compendium of engineering biographies will be available only to those placing reservations prior to publication, and urge prompt action on the part of any persons wishing to acquire the book.

Institute Policy Committee Appointed

At the May 19, 1931 meeting of the Institute's board of directors the question was raised—*should the Institute, with the object of enhancing the status of the engineering profession, devote more of its resources to non-technical activities, such, for example, as legislation, education, and the economic welfare of the engineer?*

The following resolution was adopted:

"Resolved: That the president be authorized to appoint a special committee on Institute policies for the purpose of studying the present and any proposed future activities of the Institute; this committee to invite and consider suggestions from any member, officer, or committee, and to make definite recommendations to this board regarding modifications of present activities and plans for any additional fields of work that the committee may deem desirable."

In accordance with this action, President Lee appointed the following committee:

Chairman, C. E. Stephens (M'22) (vice-president and northeastern district manager, Westinghouse Electric & Manufacturing Company, New York, N. Y.) director; present chairman of finance committee; member, committee on coordination of Institute activities, executive committee, U. S. National committee of the I. E. C., and the assembly of American Engineering Council.

Vice-Chairman, H. A. Kidder (F'29) (superintendent of motive power, Interborough Rapid Transit Company, New York, N. Y.) past-vice-president; present chairman, committee on engineering profession; member, board of examiners, law committee, assembly of American Engineering Council, and board of trustees of United Engineering Trustees, Inc.

H. P. Charlesworth (F'28) (vice-president Bell Telephone Laboratories, Inc., New York, N. Y.) vice-president New York City District; past-chairman, meetings and papers committee; chairman, committee on coordination of Institute activities; member, Edison medal, engineering profession, finance, Lamme medal, meetings and papers, and publication committees, and board of trustees of United Engineering Trustees, Inc.

F. L. Hutchinson (M'13) (national secretary, A. I. E. E.) member, committee on coordination of Institute activities, Edison medal, and publication committees, assembly of American Engineering Council, engineering societies library board.

J. A. Johnson (F'27) (chief electrical engineer Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.) director; present chairman, membership committee; member, Edison medal, executive, electrical machinery, and research committees.

E. S. Lee (F'30) (assistant engineer General Electric Laboratory, Schenectady, N. Y.) present chairman, Sections committee; member, committee on coordination of Institute activities, and instruments and measurements committee.

E. B. Meyer (F'27) (vice-president United Engineers & Constructors, Inc., Newark, N. J.) director; past-chairman, meetings and papers, and finance committees; present chairman, law committee; member, committee on coordination of Institute activities, Edison medal, finance, publication, and power generation committees.

W. S. Rodman (F'28) (professor of electrical engineering, University of Virginia) vice-president, Southern District; student Branch counselor; member, Sections and electrophysics committees, education research committee of Engineering Foundation, and assembly of American Engineering Council.

C. F. Scott (F'25 HM'29) (head of department of electrical engineering Yale University), past-president; chairman, development committee 1919; member, Lamme medal, standards and student Branches committees, assembly of American Engineering Council; past-member, many other Institute committees.

This committee held its first meeting June 8 at Institute headquarters and directed that through this notice in Electrical Engineering the membership be invited and urged to submit through the national secretary any suggestions or criticisms relating to the present activities of the Institute; also regarding any additional activities which individual members may deem desirable.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Collinot, Marcel A., 88 Sherman Ave., Newark, N. J.
Cole, Will G., Box 222, Westwood, Calif.
Corriveau, F. M., General Electric Co., Schenectady, N. Y.
Falk, Victor E., 2422 Euclid Ave., Cleveland, Ohio.
Fyler, George W., Y. M. C. A., Schenectady, N. Y.
McDonald, I. M., 772 Pollokshaws Road, Glasgow, Scotland.
Nuber, Frank J., 3831 Rokeby St., Chicago, Ill.
O'Shea, V., Jr., 115 Broadway, New York, N. Y.
Sullivan, John E., 6320 Kenmore Ave., Chicago, Ill.
Tung, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Personal

F. M. Feiker Appointed Commerce Director

The appointment of Frederick M. Feiker (M'15) managing director of the Associated Business Papers, Inc., New York, N. Y., to the office of director of the Bureau of Foreign and Domestic Commerce was announced May 29, 1931, by President Hoover. Mr. Feiker succeeds W. L. Cooper who is withdrawing to resume his former duties as commercial attaché at London, England.

Born at Northampton, Mass., Mr. Feiker received his degree of B. S. in E. E. from Worcester Polytechnic Institute, Worcester, Mass., in 1904. He has served as editor of *Factory Magazine* and *Electrical World*; chairman of the editorial board of *System* and *Factory*; and vice-president of the McGraw-Hill Publishing Company, Inc., New York, N. Y. During 1920-21 he was Acting Assistant Secretary of Commerce and served in the various capacities. Besides having been a member of the Institute for almost two decades, Mr. Feiker holds an active membership in the American Society of Mechanical Engineers and the Illuminating Engineering Society.

Harold B. Smith (F'13) past-president of the Institute and for many years head of the department of electrical engineering Worcester Polytechnic Institute, Worcester, Mass., resigned his educational chair there effective June 1931. As one well known in engineering and education Dr. Smith always has carried forth a multiplicity of duties in these fields. His share in Institute activities has been abundantly represented by service on several of its committees simultaneously, including: law 1920-21; electrolysis and student branches 1920-27; instruments and measurements 1921-22; educational 1922-27; sections 1922-28; Edison Medal 1924-26, 1929-30, 1930-31; research, coordination of Institute activities, and meetings and papers 1924-27; code of principles for professional conduct 1928-29; executive 1929-31; and public policy 1930-31. He was appointed also to the John Fritz Medal board of award for 1929-33, the U. S. national committee of the I. E. C., the Chas. A. Coffin Fellowship & Research Fund committee 1929-30, and the American Engineering Council 1930-31. It is his hope to resume professional practise.

F. V. Magalhaes (F'19) who left New York and his office as general superintendent of distribution and installation, New York Edison Company, to become vice-president of the Hall Electric Heating Company, Inc., now has been appointed general manager of his company in addition to his duties as vice-president. His professional career has been a busy one; during the past year he was vice-chairman of the Institute's committee on safety codes, an alternate representative for the Institute in the National Fire Protection Association (electrical department) and on the National Fire Waste Council; also a member of special subcommittee of the standards committee dealing with reactive power. The year previous he served at various times as a member of the Institute's board of examiners and the meetings and papers committee; was member and chairman of the A. I. E. E. committee on instruments and measurements. For several years was one of the Institute's representatives to U. S. National committee of the International Electrotechnical Committee.

H. L. Wills (A'20) inductive coordination expert as assistant to the vice-president and general manager of the Georgia Power Company, Atlanta, Ga., now has established a consulting engineering practise of his own, specializing in adjustment of relations between telephone, telegraph, railway signal, and automatic train control systems, including problems of electrolysis and radio interference. Mr. Wills was chairman of the Institute's Atlanta Section in 1921 and 1928, and has rendered much valuable service to the National Electric Light Association as a member of its inductive coordination committee (1923-27); chairman (1928-29). Mr. Wills has been active also in the association's joint operations with the Bell Telephone System (joint subcommittee on development and research, 1926-31) and with the American Railway Association's subcommittee on principles and practises (1929-31).

F. M. Denton (F'28) head of the department and professor of electrical engineering, University of Mexico, Albuquerque, N. M. has been awarded fellowship in the City and Guilds of London Institute, the highest distinction that institute confers. Only eleven of its several thousand graduates since the inauguration of its Fellow in E. E. degree have received it; it was awarded to Mr. Denton as one "of a limited number of Associates (ACGI) with not less than five years of actual practise and having contributed to advancement of the industry." The City and Guilds College (School of the University of London) is said to be the foremost of engineering schools in the British Empire.

D. Levinger (M'30) engineer of manufacture, Western Electric Company, recently was elected one of its directors, the youngest member of the company's board. Already he has served the company for 21 years and now as its engineer of manufacture heads a large force of trained engineers and scientists. He is a member of the Institute of Mining and Metallurgical Engineers, and has served three years upon its research committee; he also is a member of the American Society of Mechanical Engineers, the American Society for Steel Treating, and the American Association for the Advancement of Science.

R. F. Pack (M'12) recently elected president of the Northern States Power Company has been identified with the electrical industry since 1891 when he engaged as office boy with the Toronto Electric Light Company. He was instrumental in the affiliation between the Canadian Electrical Association and the National Electric Light Association in the affairs of which he has always remained active. He worked with B. Gherardi (F'12 and past-president) vice-president of the A. T. & T., in improving harmonious relations between these two great industries.

T. H. Clegg (M'21) who has been affiliated with the Philadelphia Rapid Transit Company as special engineer, on June 1, 1931, opened his own consulting offices at the same address, 1600 Walnut Street, Philadelphia, Pa. In the past, Mr. Clegg's work has been of a confidential nature appertaining to power investigations, and to the operation and management of power plants. For the past three years he has served the American Electric Railways Association on committees dealing with power contracts and mercury-arc rectifiers.

C. E. Skinner (F'12) assistant director of engineering, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., upon June 8, 1931, received the Lamme Medal annually awarded by Ohio State University to an alumnus "for meritorious achievement in engineering or the technical arts." Mr. Skinner has done much conspicuous professional work in many fields of electrical application. He has served the American Society of Testing Materials (1917-18), the Engineering Council (1917-19), and American Engineering Council (since 1923).

W. R. Whitney (A'01) vice-president and director of the research laboratory, General Electric Company, Schenectady, N. Y., was awarded the Franklin Medal of the Franklin Institute May 20, 1931. The award, which this year took place at Philadelphia, is made annually to "workers in physical science or technology without regard to country, whose efforts in the opinion of the administering committee on science and arts, have done most to advance a knowledge of physical science or its application."

Joseph O. Phelon (M'13) for 44 years identified with the Worcester Polytechnic Institute, Worcester, Mass., retired from the office of professor of electrical engineering June 1931. For several years after his graduation from that Institute, he taught in its physics department, but in 1896 he was transferred to the newly formed department of electrical engineering where he has served as full professor since 1907 and as head of the department in 1911-13. He now plans to make California his place of residence.

W. S. Gifford (A'16) president, American Telephone & Telegraph Company, New York, N. Y. has been elected a member of the board of trustees of Cooper Union, New York City, to succeed Thomas Snell, deceased. This continues a tradition of service to Cooper Union by men in the forefront of industry and public affairs.

W. F. Fenninger (M'22) who has been serving as supervisor of electric courses at the Rochester (N. Y.) Mechanics Institute, is now state supervisor of technical and cooperative education, with headquarters at Albany. In this capacity he visits the several high schools in which technical courses are given offering suggestions to bring them up to State standards or for maintaining these standards if already achieved.

M. K. McGrath (M'27) who has been serving as vice-president of the International Telephone & Telegraph Corporation, Aldwych, London, W. C. 2, England, left there June 6, 1931, to take up residence in America. His address for the present will be in care of the International Telephone & Telegraph Corporation, New York, N. Y.

L. C. Armitage (A'28) who has been industrial heating engineer for the General Electric Company, Schenectady, N. Y. has now become designing engineer for the Ajax Electric Company, Inc., at Philadelphia, Pa. where his principal work will be the design and development of a variable temperature electric decorating kiln.

R. D. Bean (A'21) formerly manager of the engineering development department of The Brown Instrument Company, Philadelphia, has been made chief engineer of that company. Mr. Bean's extensive field investigations cover many applications of measuring instruments.

F. J. Airey (A'19) division manager of the General Electric Supply Corporation at Los Angeles, Calif., has been elected chairman of the National Electric Wholesalers' Association. He has been 42 years in the business of electrical merchandising.

B. L. Robertson (A'26) assistant professor of electrical engineering, Pennsylvania State College, State College, Pa., has left the East to enter the department of electrical engineering of the University of California at Berkeley, Calif.

H. C. Wolfe (A'28) recently has become associated with the Empire Industries, Inc., Cleveland, Ohio, as its president. His work with the company will be the development of industrial application of chromium plate for engine parts, turbine blades, molds, and various tools and dies.

R. D. McCarter (M'09) who has been doing a consulting engineering business in New York City, has joined the European Gas & Electric Company, Aldwych, London, W. C. 2, England.

Obituary

H. Eugene Chubbuck (F'13) retired operating head of the Illinois Traction System, Inc., whose name is closely linked with the story of electricity and its application, died June 4, 1931 in Peoria, Illinois, after an extended illness. He was born in Utica, New York, and educated in the public schools of that city supplemented by one year at Whitestown Seminary and later a special course in chemistry and physics. In 1880 he returned to Whitestown as instructor in these subjects. He devoted the years 1881-1883 to shop practise in telegraph and philosophical instruments, the last year for the greater part being spent on electric lighting and testing machinery. In 1883 he engaged with the Thomson Houston Company as an expert and installed the first lighting plant at Pawtucket, R. I. The Narragansett Electric Company of Providence, R. I. next appointed him as its electrical engineer, a service occupying him for one year, and terminating in his return to special expert and construction work for Thomson Houston. In 1898 he joined the General Electric Company for special work and was given charge of its sales offices at Salt Lake City. He was the son of A. S. Chubbuck and grandson of S. W. Chubbuck, both well known to the profession for establishing the manufacture of telegraph machinery, and the building of some of the first instruments used. Mr. Chubbuck joined the Institute as an Associate four years after its organization, when the grade of Associate was the compulsory initial grade.

T. H. U. Aldridge (F'18) vice-president and general manager of the Shanghai Power Company, Shanghai, China, died suddenly on the 10th of May, 1931. A native of London, England (1874), his residence in China dates back to 1901 when he accepted appointment as municipal electrical engineer to the International Municipal Council of Shanghai. By the end of 1916 his staff had increased from three Europeans and 120 Chinese to 76 Europeans and 1,099 Chinese. As engineer-in-chief and manager of the municipal electricity department Mr. Aldridge was directly responsible to the electricity committee for both technical and commercial direction of undertaking as well as matters involving finance. He was responsible also for the general design and layout of two large power stations including all essentials of a central station light, heat, and power system. During his régime the system was converted from single-phase, 100-cycle, 2,000-volt generation and distribution to a modern 50-cycle system. The annual report of the Shanghai Municipal Council's electricity department (1917) attests the success of his undertakings.

Carlyle Kittredge (F'22) assistant to the vice-president of the Michigan Bell Telephone Company, Detroit, Mich., and for many years its chief engineer, died in the Harper Hospital that city May 23, 1931, the result of an operation for acute appendicitis. He was born at Mason, Mich., July 19, 1874. As past-chairman of the Institute's Detroit-Ann Arbor Section (1921) he has been specially active for its interests. He also was a member of the Detroit Engineering Society. In 1897 he was graduated from the University of Michigan with the degree of B. S. in E. E., and two years later joined the Electric Light & Power Company, Van Wert, Ohio, as its superintendent. In 1900 he engaged with the Central Union Telephone Company, doing special inspection work in Ohio, Indiana, and Illinois, ultimately becoming assistant chief engineer. On August 15, 1911, he joined the Michigan State Telephone Company as plant engineer, a position which he held until 1920 when he became chief engineer. At the time of his death he was secretary of the Wolverine section of the Telephone Pioneers of America.

Jay L. Stannard (M'29) chief engineer of the department of public utilities, City of Tacoma, Washington, died March 13, 1931 having been ill less than a month. He was a native of Chittenango, N. Y. (1866); after two years in common and high school at Shell Rock, Iowa, he spent two years at Cornell

College, Mount Vernon, Iowa. Until 1887 his time was occupied chiefly with a civil engineering practise. For the next ten years he acted as engineer for the contractor on several of the power and lighting projects of the Pacific Coast. Prior to his arrival in Tacoma (1923) Mr. Stannard had been identified with many irrigation, water works, and power plant developments along the Pacific Coast; the Grant Smith Company project in California, the Cedar River plant at Seattle, and the Bull Run plant at Portland. From 1912 to 1919 he was consulting engineer for the North Coast Power Company in Portland. At the time of his death he was serving his second term as president of the Tacoma Section of the American Society of Civil Engineers, which he had been instrumental in establishing.

William F. Callahan (A'23) engineering assistant, Western Union Telegraph Company, New York, N. Y., died May 31, 1931, at the age of forty. After the completion of studies in machine design, manual training and applied electricity at Pratt Institute, his first business connection (1910) was when he joined the Western Electric Company, New York, with which he remained as machine hand and inspector until 1913; then he became draftsman of Bramhall Deane & Company, Brooklyn, N. Y. In March 1914 he engaged with the Western Union Telegraph Company, New York City, spending three years as draftsman, followed almost immediately by appointment as engineering assistant, the position he held until his death. Mr. Callahan belonged to the Institute's New York Section, in which he was active.

Local Meetings

Utah Section and Branch Meet

The Utah Section and the University of Utah Branch held their annual joint meeting for the presentation of a student program on May 18. This was the last meeting of the Section for the present administrative year.

The following papers were presented by students:

Keying of Continuous-Wave Transmitters, by M. R. Johnson and L. K. Irvine.

Illumination of the University Campus, by L. D. Schroder and J. O. Carlston.

Stroboscopic Effects with Neon Glow Tubes, by Courtney Campbell.

Investigation of the Acoustics of Kingbury Hall, by Fred Lundberg and F. M. Neal.

Oklahoma City Section Meets with Branches

The annual joint meeting of the Oklahoma City Section and the student Branches at the University of Oklahoma and the Oklahoma A. & M. College was held at the latter school on May 18, 1931. During the morning program students of the two schools presented the following technical papers:

Choice of Petroleum Pump Station Equipment, by V. J. Sittel, Oklahoma A. & M College.

Factors Determining the Rating of Underground Cables, by Wm. M. Achgill, A. B. Bartow, T. A. Bloss, University of Oklahoma (presented by Wm. M. Achgill).

Grounds and Methods of Testing Them, by Hubert I. Short, Oklahoma A. & M. College.

System Solution by the Method of Symmetrical Components, by R. J. Thompson, University of Oklahoma.

Thyratron Tube and Its Recent Applications, by W. E. Nichols, Oklahoma A. & M. College.

Radio Field Intensity Survey, by G. S. Hammonds, University of Oklahoma.

Transmission Lines: Generator-End Requirements versus Load Constants, by P. H. Foster, Oklahoma A. & M. College.

Application of Kirchoff's Laws and Superposition of Currents in Calculating Loop and Network Circuits, by S. Alexander, University of Oklahoma.

The program was followed by a luncheon (attended by about 115) and the inspection of engineering laboratories.

At an afternoon session authors of three papers were awarded prizes as follows:

First prize ($15) S. Alexander, University of Oklahoma

Second prize ($10) Waldo E. Nichols, Oklahoma A. & M. College

Third prize ($5) Hubert I. Short, Oklahoma A. & M. College

Mr. Alexander, winner of first prize, recently has won a Tau Beta Pi scholarship for $750 and a $500 tuition scholarship from the Massachusetts Institute of Technology. In his freshman year he received a $1,000 prize offered for the best paper by the American Chemical Society.

The following names of officers of the Oklahoma City Section for next year were announced: C. T. Almquist (A'28) associate professor of electrical engineering, University of Oklahoma, chairman; A. Naeter (M'30) head electrical engineering department, Oklahoma A. & M. College, vice-chairman; and C. E. Bathe (A'29), superintendent of radio and standards, Oklahoma Gas & Electric Co., secretary-treasurer.

Section and Branch Join in Meeting at Cincinnati

The annual joint meeting of the Cincinnati Section and the University of Cincinnati Branch was held at the university on May 14, with an attendance of 80; the preceding dinner was attended by 38.

The following program was presented by seniors in electrical engineering:

Choke-Coil Design, by D. T. Michael.

Study of a Spot Welder, by F. F. Osterholz.

Study of a 500-Cycle Generator, by G. H. Pettibone.

Experimental Study of Means of Lessening Static in Receiving Sets, by G. F. Platts.

Speed Control of a D-C. Motor, by R. M. Seitz.

Pitting in Telephone Relay Contacts, by Henry Suter.

Baltimore Section Awards Prizes

Each alternate year the Baltimore Section has a prize paper meeting. For the contest this year six papers were submitted for three of which the following prizes were awarded at this meeting:

First prize: ($25)—W. P. Taylor, Consolidated Gas Electric Light and Power Company. Locating Power Cable Faults by Means of a Constant Current Transformer with Short Circuiting Switch.

Second prize: ($15)—L. J. Berherich, graduate student, Johns Hopkins University, A Method for Measuring the Phase Angles of Shielded Resistors.

Third prize: ($10)—G. M. L. Sommerman, graduate student, Johns Hopkins University, The Spark Discharge in Air.

The speakers were invited to an executive dinner preceding the regular meeting. The following officers were elected for the year 1931-32; chairman K. A. Hawley (M'12) chief engineer Locke Insulator Corporation; vice-chairman L. G. Smith (M'25) assistant to general superintendent, Consolidated Gas Electric Light & Power Corporation; secretary-treasurer J. Wells (A'27) development manager Western Electric Company.

Faraday Discoveries Celebrated at Lehigh University

In honor of the centennial of Faraday's discovery of electromagnetic induction, engineering students at Lehigh University, Bethlehem, Pa., under the leadership of the local student Branch of the Institute, held a special joint meeting April 29, 1931. Members of the several engineering societies at Lehigh presented papers descriptive of different phases of Faraday's scientific work and staged apparatus demonstrations designed to commemorate Faraday's more important discoveries.

Eight students cooperated in the preparation and presentation of five papers as follows:

1. FARADAY THE MAN, by F. W. Matchett, M. E. '31.
2. CONTRIBUTION TO CHEMISTRY, by R. C. Smith, Chem. '31 and L. S. Millelot, Chem. '31.
3. CONTRIBUTION TO METALLURGY, by W. H. Wagner, Met. E. '31 and J. S. Harrison, Met. E. '31.
4. ELECTROMAGNETIC INDUCTION, by R. E. Snyder, E. E. '31 and L. R. Wanner, E. E. '31.
5. OPTICS, by D. L. MacAdam, Engg. Physics '32.

Past Section Meetings

Akron

SOME ENGINEERING FEATURES IN CONNECTION WITH HEAVY CONSTRUCTION, by W. S. Lee, president, A. I. E. E. Illustrated by several reels of motion pictures. Dinner meeting. Election of officers for 1931-32: R. R. Krammes, chairman; R. A. Hudson, secretary; P. C. Smith, treasurer. May 22. Attendance 50.

Boston

Annual meeting and election of following officers: C. A. Corney, chairman; F. D. Hallock, vice-chairman; G. J. Crowdes, secretary-treasurer. Motion pictures and other entertainment remainder of the evening. May 14. Attendance 121.

Cincinnati

W. Weftendorp, General Electric Company, spoke on the study of the light penetration and its detection through fog. A representative of the Army Air Corps of Dayton outlined Army preparedness plans with particular reference to obtaining materials and construction for airplanes. Dinner preceded the meeting. May 5. Attendance 250.

Annual golf tournament and dinner preceded the evening meeting at which Prof. F. H. Bird, University of Cincinnati, spoke on ECONOMIC PHASES OF CITY DEVELOPMENT. Election of officers: E. S Fields, chairman; J. A. Noertker, secretary-treasurer. June 4. Attendance 46.

Connecticut

Annual outing and dinner dance. May 23. Attendance 115.

Dallas

LEAD STORAGE BATTERIES AND THE FUNDAMENTAL PRINCIPLES OF BATTERY OPERATION AND MAINTENANCE, by W. E. Dunn, Electric Storage Battery Company. Election of officers: Gibbs A. Dyer, chairman; S. M. Sharp, secretary-treasurer. May 25. Attendance 104.

Denver

Business meeting. May 12. Attendance 17.

Detroit-Ann Arbor

THE ELECTRICAL INDUSTRY AND ELECTRICAL ENGINEERING IN SOVIET RUSSIA, by A. Dovjikov, Westinghouse Elec. & Mfg. Company. Prior to this talk many members inspected the Moore's Park station of the City of Lansing. May 19. Attendance 200.

Erie

VACUUM TUBES, by A. W. Hull, General Electric Company. Election of officers: P. R. Urich, chairman; C. V. Roberts, secretary. May 19. Attendance 83.

Houston

STORAGE BATTERIES, by W. E. Dunn, Electric Storage Battery Company. J. S. Waters elected secretary. May 26. Attendance 15.

Indianapolis-Lafayette

VACUUM-TUBE CONTROL, by S. D. Fendley, General Electric Company. May 15. Attendance 94.

Iowa

RAILROAD ELECTRIFICATION DEVELOPMENTS IN AMERICA AND ABROAD, by F. W. Peters, General Electric Company. Joint meeting with the Des Moines Engineers Club and the Des Moines Architects Club. Election of officers: H. B. Hoffhaus, chairman; E. W. Schilling, secretary-treasurer. May 14. Attendance 90.

Ithaca

Election of officers: W. E. Meserve, chairman; B. K. Northrop, secretary-treasurer. Dinner meeting. May 29. Attendance 13.

Lehigh Valley

Annual meeting and exhibition at which applications of the photoelectric cell, metering equipment, and other recent electrical developments were displayed by various manufacturers. Preceding dinner the following motion pictures were shown: "Dynamic America," "The Romance of Power," "Deion Oil Circuit Breakers." Reports from the chairmen of the local committees were read and officers for the year 1931-32 were announced. PLANNING TO AVOID DEPRESSIONS, by E. C. Stone, vice-president A. I. E. E. District No. 2, was presented by R. L. Kirk, Duquesne Light Company. May 16. Attendance 135.

Los Angeles

Two papers concerning the R. C. A. 50-kw. broadcasting transmitter being installed for KFI, were presented by J. J. Farrell and G. W. Fyler, both of the General Electric Company. Election of officers as follows: P. S. Biegler, chairman; F. E. Dellinger, secretary. Joint meeting with the Institute of Radio Engineers. May 19. Attendance 203.

Louisville

Annual meeting. Reports of local committees were read, and election of officers was made as follows: Philip P. Ash, chairman; C. M. Ewing, secretary-treasurer. Dinner and entertainment followed. June 4. Attendance 37.

Memphis

POWER PLANT GENERATION AND UTILIZATION, by Robert Bruce, Memphis Power and Light Company;

THE NEW 110-KV. RIVER CROSSING, by M. Eldredge, Memphis Power & Light Company, and chairman, Memphis Section. May 12. Attendance 42.

FUSELESS HOME, by H. G. Nichols, Westinghouse Elec. & Mfg. Company. June 9. Attendance 36.

Milwaukee

Inspection trip through the Globe-Union Mfg. Company plant, and talk by W. R. Vicarey of that company on

College, Mount Vernon, Iowa. Until 1887 his time was occupied chiefly with a civil engineering practise. For the next ten years he acted as engineer for the contractor on several of the power and lighting projects of the Pacific Coast. Prior to his arrival in Tacoma (1923) Mr. Stannard had been identified with many irrigation, water works, and power plant developments along the Pacific Coast; the Grant Smith Company project in California, the Cedar River plant at Seattle, and the Bull Run plant at Portland. From 1912 to 1919 he was consulting engineer for the North Coast Power Company in Portland. At the time of his death he was serving his second term as president of the Tacoma Section of the American Society of Civil Engineers, which he had been instrumental in establishing.

William F. Callahan (A'23) engineering assistant, Western Union Telegraph Company, New York, N. Y., died May 31, 1931, at the age of forty. After the completion of studies in machine design, manual training and applied electricity at Pratt Institute, his first business connection (1910) was when he joined the Western Electric Company, New York, with which he remained as machine hand and inspector until 1913; then he became draftsman of Bramhall Deane & Company, Brooklyn, N. Y. In March 1914 he engaged with the Western Union Telegraph Company, New York City, spending three years as draftsman, followed almost immediately by appointment as engineering assistant, the position he held until his death. Mr. Callahan belonged to the Institute's New York Section, in which he was active.

Local Meetings

Utah Section and Branch Meet

The Utah Section and the University of Utah Branch held their annual joint meeting for the presentation of a student program on May 18. This was the last meeting of the Section for the present administrative year.

The following papers were presented by students:

Keying of Continuous-Wave Transmitters, by M. R. Johnson and L. K. Irvine.

Illumination of the University Campus, by L. D. Schroder and J. O. Carlston.

Stroboscopic Effects with Neon Glow Tubes, by Courtney Campbell.

Investigation of the Acoustics of Kingsbury Hall, by Fred Lundberg and F. M. Neal.

Oklahoma City Section Meets with Branches

The annual joint meeting of the Oklahoma City Section and the student Branches at the University of Oklahoma and the Oklahoma A. & M. College was held at the latter school on May 18, 1931. During the morning program students of the two schools presented the following technical papers:

Choice of Petroleum Pump Station Equipment, by V. J. Sittel, Oklahoma A. & M College.

Factors Determining the Rating of Underground Cables, by Wm. M. Achgill, A. B. Bartow, T. A. Bloss, University of Oklahoma (presented by Wm. M. Achgill).

Grounds and Methods of Testing Them, by Hubert I. Short, Oklahoma A. & M. College.

System Solution by the Method of Symmetrical Components, by R. J. Thompson, University of Oklahoma.

Thyratron Tube and Its Recent Applications, by W. E. Nichols, Oklahoma A. & M. College.

Radio Field Intensity Survey, by G. S. Hammonds, University of Oklahoma.

Transmission Lines: Generator-End Requirements versus Load Constants, by P. H. Foster, Oklahoma A. & M. College.

Application of Kirchoff's Laws and Superposition of Currents in Calculating Loop and Network Circuits, by S. Alexander, University of Oklahoma.

The program was followed by a luncheon (attended by about 115) and the inspection of engineering laboratories.

At an afternoon session authors of three papers were awarded prizes as follows:

First prize ($15) S. Alexander, University of Oklahoma

Second prize ($10) Waldo E. Nichols, Oklahoma A. & M. College

Third prize ($5) Hubert I. Short, Oklahoma A. & M. College

Mr. Alexander, winner of first prize, recently has won a Tau Beta Pi scholarship for $750 and a $500 tuition scholarship from the Massachusetts Institute of Technology. In his freshman year he received a $1,000 prize offered for the best paper by the American Chemical Society.

The following names of officers of the Oklahoma City Section for next year were announced: C. T. Almquist (A'28) associate professor of electrical engineering, University of Oklahoma, chairman; A. Naeter (M'30) head electrical engineering department, Oklahoma A. & M. College, vice-chairman; and C. E. Bathe (A'29), superintendent of radio and standards, Oklahoma Gas & Electric Co., secretary-treasurer.

Section and Branch Join in Meeting at Cincinnati

The annual joint meeting of the Cincinnati Section and the University of Cincinnati Branch was held at the university on May 14, with an attendance of 80; the preceding dinner was attended by 38.

The following program was presented by seniors in electrical engineering:

Choke-Coil Design, by D. T. Michael.

Study of a Spot Welder, by F. F. Osterholz.

Study of a 500-Cycle Generator, by G. H. Pettibone.

Experimental Study of Means of Lessening Static in Receiving Sets, by G. F. Platts.

Speed Control of a D-C. Motor, by R. M. Seitz.

Pitting in Telephone Relay Contacts, by Henry Suter.

Baltimore Section Awards Prizes

Each alternate year the Baltimore Section has a prize paper meeting. For the contest this year six papers were submitted for three of which the following prizes were awarded at this meeting:

First prize: ($25)—W. P. Taylor, Consolidated Gas Electric Light and Power Company. Locating Power Cable Faults by Means of a Constant Current Transformer with Short Circuiting Switch.

Second prize: ($15)—L. J. Berherich, graduate student, Johns Hopkins University, A Method for Measuring the Phase Angles of Shielded Resistors.

Third prize: ($10)—G. M. L. Sommerman, graduate student, Johns Hopkins University, The Spark Discharge in Air.

Pre-Faraday Developments, by I. Olcovich;

Typical Faraday Experiments, by A. Gessell;

Later Developments, by E. R. Gaerttner. After these talks the laboratories were open for inspection. May 22. Attendance 60.

Election of officers: L. C. Grussler; E. R. Gaerttner, vice-president; Irwin Olcovich, secretary-treasurer. May 26. Attendance 15.

Film—"Turbine with Solid Rotor." June 2. Attendance 16.

University of Detroit

Fourth annual banquet held at the Cadillac Athletic Club. Election of officers: Bernard Sharkey, chairman; P. Zoufal, vice-chairman; John Schenk, secretary; Thomas M. Ward, treasurer. June 3. Attendance 60.

University of Florida

Measurement of Ground Resistances, by A. W. Harris, student. May 13. Attendance 25.

Harvard University

The Queenston-Chippawa Power-Development, by R. Bullwinkle, student;

Public Utilities, by Eric A. Walker, student;

The A. I. E. E. North Eastern District Meeting at Rochester, by J. H. Wright, student. Election of officers: Eric A. Walker, chairman; Robert D. Hickok, Jr., vice-chairman; Charles N. Mason, secretary-treasurer. May 19. Attendance 14.

Inspection trip to the toll exchange of the New England Telephone and Telegraph Company, Boston. May 21. Attendance 10.

Iowa State College

Election of officers: W. L. Huebner, president; W. Hardman, vice-president; G. Franks, secretary; M. Cain, treasurer. May 22. Attendance 21.

Kansas State College

Election of officers: G. E. Cain, president; D. E. West, secretary. May 14. Attendance 100.

Lehigh University

The History of the Electrical Industry, by J. M. Bisbee, student;

Developments in the Electrical Field in 1930, by J. F. Miller, student;

Solution of Lightning Problems, by J. B. Sponsler, student. Election of officers: L. F. Underwood, president; J. D. Brown, vice-president; J. J. Grinevich, treasurer; C. W. Banks, secretary. May 13. Attendance 40.

Lewis Institute

Business meeting. Prof. F. A. Rogers nominated for counselor. May 1. Attendance 15.

Inspection trip to the plant department of the American Tel. & Tel. Company. June 3. Attendance 17.

How I Got into Engineering, by A. B. Smith, Automatic Electric Company. June 5. Attendance 68.

Michigan State College

Illustrated talk given by F. Harbin, student, featuring a film entitled "Radio Communication on Trains." May 12. Attendance 23.

Several talks by students and a demonstration of the "Telemat." Joint meeting with the University of Michigan Branch. May 28. Attendance 32.

To Find the Maximum Span of a Catenary if the Density, Tensile Strength, and Gravity Remain Constant, by L. Switzgable, student;

Discussion of the Effect of Division of Load upon Rotary Converter Systems, by G. T. Hittle, student. Explanation of the recording interferometer given by Prof. C. W. Chamberlain. June 9. Attendance 29.

University of Michigan

Business discussion. May 13. Attendance 16.

Annual banquet at which the following program was presented:

Joseph Henry, by L. C. Poole, student;

A Russian Meets a Turk, by P. D. Kalachov, student;

Michael Faraday, by L. Zanoff, student;

The Hand is Quicker than the Eye, by Prof. A. D. Moore;

Before the Drought, by Dean Emeritus M. E. Cooley. May 26. Attendance 60.

School of Engineering of Milwaukee

Life of Steinmetz, by J. D. Ball, vice-president of the school. May 13.

University of Minnesota

Tenth biennial electrical engineers' party. April 17-18. Attendance 4,100.

Banquet meeting. Election of officers: Martin G. Swanson, chairman; Harold L. Ericson, vice-chairman; Scott McDermott, secretary-treasurer. May 19. Attendance 33.

Mississippi A. & M. College

Election of officers: J. M. Caldwell, chairman; C. R. Lillybridge, vice-chairman. May 20. Attendance 27.

University of Missouri

The Possibilities in Engineering, by R. V. Wright, president of A. S. M. E. Joint meeting with the A. S. M. E., A. S. C. E., and A. I. Ch. E. April 30. Attendance 43.

Audible Light, by J. B. Taylor, General Electric Company. May 18. Attendance 176.

Montana State College

Transformer Design, by R. Bjork, student;

Volta Power Plant, by N. Hovey, student;

Black Eagle Plant, by T. Micka, student. May 14. Attendance 99.

The Electrical Show at Washington State College, by W. Rightmire, student;

The Impedance Bridge, by P. O. Koetitz, student;

Office Illumination, by R. Rydell, student. May 21. Attendance 94.

University of Nebraska

The Lincoln Telephone & Telegraph Company's first aid team gave a demonstration covering the high points of first aid work. May 13. Attendance 45.

University of Nevada

Election of officers as follows: Donald Knapp, chairman; Calvin Dodson, vice-chairman; Orvis Reil, secretary-treasurer. May 3. Attendance 21.

University of New Hampshire

Moving pictures and talks by E. J. Shaw and L. M. Shampeau, both of the Westinghouse Elec. & Mfg. Company. May 6. Attendance 56.

Talk by W. S. Keay, New England Gas & Electric Association. May 20. Attendance 80.

Business meeting. May 27. Attendance 16.

University of New Mexico

Smoker. Economics of Neon Lighting, by E. Huffman and H. Mendenhall, students. H. Bangerter and S. Pelatowski, students, gave a demonstration of some of the effects of ultra-short radio waves. May 28. Attendance 21.

College of the City of New York

Transmission of Power, and High-Voltage Insulators, by Mr. Wildebrandt, Ohio Insulator Company. May 21. Attendance 15.

University of North Carolina

Engineering in the Latin Countries, by Professor Bennett. May 14. Attendance 23.

North Dakota State College

Radio Broadcasting, by D. F. Holaday, student;

Magnetism, by B. Weiss, student;

Michael Faraday, by E. Blomquist, student;

Some Actual Experiences, by R. Stockstad, student;

Life After Graduation, by Professor H. Rush, counselor;

Relations of Industry to College Men, by J. D. Taylor, Northwestern

Bell Telephone Co. May 27. Attendance 15.

University of North Dakota

Photoelectric Cells and Applications, by Eugene Becken, student;

The Institute and Its Functions, by Prof. H. F. Rice, counselor. May 13. Attendance 28.

University of Notre Dame

Annual picnic. May 16. Attendance 160.

The Marvels of Sound Transmission, by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. May 19. Attendance 1,300.

Ohio Northern University

Banquet meeting. Electrical Engineers in Industry, by Prof. A. D. Moore. Election of officers: O. R. Jacobs, president; B. Wyant, vice-president; W. Gideon, secretary; O. Hawes, treasurer. May 29. Attendance 75.

Ohio State University

Demonstrations were performed by the students using the new equipment just acquired for the electrical engineering department. May 1. Attendance 60.

Ohio University

The Large Differences Which Are Made by the Little Differences in Men, by Dr. E. B. Bryan, president of the University. Election of officers: George Wyckoff, chairman; William Miller, vice-chairman; William Cooper, secretary-treasurer. May 6. Attendance 41.

Oregon State College

Submarine Cables, by E. D. Pearson, North Western Electric Company. S. B. Clark, of the same company, supplemented this talk by describing the manufacture of submarine cables. Election of officers: Dale Hansen, president; Elliott MacCracken, vice-president; George Howie, secretary; Stewart Kibbe, treasurer. May 12. Attendance 71.

Pennsylvania State College

Report of Oscillographic Studies of the Sources of Commutator Ripples in D-C. Machinery with Particular Reference to the Rotary Converters, by Messrs. Conrad, Forster, Foster, and Pollock, students;

Report of Capacitor Induction Motor Studies, by Messrs. Henderson, Kennedy, Lauth, and Sauter; students;

Demonstration of the Stroboscopic Possibilities of the Neon Lamp, by W. W. Harris, student.

Illustrated lecture on Alaskan Salmon Fisheries, by Prof. B. L. Robertson. May 18. Attendance 40.

Purdue University

Two films shown—"Voices Across the Sea" and "By-Products of a Telephone Research Laboratory." Election of officers: P. O. Peterson, president; M. W. Brown, vice-president; E. M. Sharer, secretary; G. K. Miller, treasurer. May 15. Attendance 30.

Rhode Island State College

Business meeting. May 27. Attendance 6.

Rice Institute

Election of officers: M. E. Kattmann, chairman; H. A. Martin, vice-chairman; E. A. Turner, Jr., secretary; R. C. Bearmann, treasurer. May 13. Attendance 20.

University of South Carolina

Alexander Graham Bell, by W. O. Farnam, student;

Sound with Pictures, by R. L. Phillips, student;

Silver Selenide with a Secret Metal Used by a German to Get Electricity from Solar Rays, by J. T. Sanders, student;

The X-Ray—New Watch-Dog of Safety, by J. B. Dent, student. May 18. Attendance 31.

Annual banquet. May 16. Attendance 16.

Thomas Alva Edison, by W. E. Crum, student;

The Variable Mu Tetrode, by J. W. Palmer, student;

A South Carolinian—W. S. Lee, by C. D. Caughman, student. May 11. Attendance 29.

University of Southern California

Recent Developments in the Electrical Industry, by W. F. Grimes, Westinghouse Elec. & Mfg. Company. April 22. Attendance 23.

Chain Broadcasting, by Paul Johnson, Pacific Tel. & Tel. Co. April 29. Attendance 26.

Application of Electricity in the Oil Fields, by C. J. Ruzicka, Standard Oil Company. May 6. Attendance 26.

Layout of Substations on the 220-Kv. Distribution System of the Edison Company, by J. M. Gaylord, Southern California Edison Company, Ltd. May 13. Attendance 26.

H. M. Cox, Bureau of Power & Light, gave instructions on artificial respiration and some useful hints on first aid, with special reference to burns which might be received by an electric current. Election of officers: M. C. Marshall, chairman; John Ganzenhuber, vice-chairman; Louis Bayha, secretary; Oliver Jessen, treasurer. May 20. Attendance 28.

Development of the U. S. Motors Corporation, by W. M. Hogne, of that company. May 27. Attendance 31.

Stanford University

Life and Work of Michael Faraday, by G. W. Dunlap, student;

Experiences at the General Electric Test Course. by M. Born, student. May 19. Attendance 12.

Residual Currents and Voltages in Electrical Power Systems, by G. H. Kimball and C. A. Bairos, students. June 2. Attendance 10.

Election of officers: Madison R. Jones, Jr., chairman; G. W. Dunlap, vice-chairman; Ronald H. Born, secretary-treasurer. June 5.

University of Tennessee

Mercury Vapor Lamps, by H. DuBose, student. Election of officers: H. M. Patterson, chairman; G. L. Dyer, vice-chairman; C. T. Nunley, secretary-treasurer. May 5. Attendance 13.

University of Texas

Research and Industry, by E. L. Manning, General Electric Company. Joint meeting with the A. S. M. E. and A. S. C. E. April 22. Attendance 60.

Theory and Applications of Electric Relays, by H. P. Robinson, Houston Power & Light Company. May 15. Attendance 23.

Virginia Polytechnic Institute

Election of officers: R. E. McDaniel, chairman; M. W. Bowery, vice-chairman. May 29. Attendance 20.

West Virginia University

Light Beams to Operate Traffic Signals, by C. E. Higgins, student;

The Du Pont Ammonia Plant at Charleston, W. Va., by H. A. Lewis, student;

Safety at Night for the Aviator, by V. S. Monteith, student;

Your Nimble Servant—The Electron, by P. J. Johnson, student. May 5. Attendance 15.

Washington State College

The Vacuum-Tube Voltmeter, by Mr. Emigh, student;

Short Circuits on Main Transmission Lines, by Mr. Holmes, student. May 8. Attendance 13.

Washington University

General discussion. May 14. Attendance 18.

University of Wisconsin

Film—"Electrical Measuring Instruments." April 28. Attendance 40.

Business meeting. May 26. Attendance 20.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ENGINEER, E. E. degree, age 30, married. Wide experience in layout, design, and research of small electrical parts, radio, motion picture and sound system apparatus. Desires position in laboratory or drafting room. A-1 references. Available immediately. Location, New York. B-5138.

GRADUATE MECHANICAL-ELECTRICAL ENGINEER, married. Nine years in public utility, testing, substation construction. One year with consulting engineer. Eight years electrical engineer, central department for group of large industrial plants; layout, operation, power distribution, economy. Three years electrical, process engineer, manufacturing plant; development, efficiency, supervision. Excellent references. East preferred. Available short notice. C-9312.

DEVELOPMENT AND RESEARCH ENGINEER, B. S. in E. E., M. S. in physics, 34, married. Four years' experience in one of largest research laboratories in electromagnetic problems and measuring instruments, knowledge of radio-frequency circuits and vacuum tubes, have patents granted, high designing and supervising skill. Desires position with future. C-9333.

CHIEF ELECTRICIAN AND MANUFACTURING ENGINEERING ASSISTANT, technical graduate, 34. Fourteen years' experience covering electrical installation, operation, and maintenance, and the manufacturing of mechanical and electrical parts. Desires position as plant electrician, testing of electrical machinery or apparatus, or engineering assistant. Moderate salary to start. Location, Northern New Jersey or vicinity. C-9305.

GRADUATE ELECTRICAL ENGINEER of Purdue University with eighteen years' experience in design, construction, estimating, costs, valuation and appraisal of power plants, substations, transmission lines and industrial plants including five years in heavy electric traction and rapid transit work. Open for opportunity with future. C-8256.

ELECTRICAL ENGINEER, 1930 graduate, 22, single. One year on the Westinghouse Student Course. Desires position as instructor in electrical engineering. Available school year 1931-1932. References. Location, immaterial. C-9311.

ELECTRICAL CONSTRUCTION ENGINEER, age 45; 25 years' experience. Has a broad technical knowledge, and extensive practical experience in commercial and industrial power and lighting construction including underground, power house and substation installations and railway electrification work. Has a thorough knowledge of estimating and valuation work and the supervising of construction forces. C-1140.

ELECTRICAL ENGINEER, 27, single, graduate of German college, six years' experience in design, research, and test on magnets, fractional horsepower motors, and control systems for mine hoists and elevators with leading American and German concerns. Desires position where knowledge of theoretical and practical is of importance. C-9810.

ELECTRICAL AND ILLUMINATING ENGINEER, 42 years old, 23 years' experience, electrician, superintendent, estimator, engineer, instructor. Power station, commercial and industrial building wiring, etc. Seven years in engineering for architects, office buildings, theaters, hotels, schools, hospitals, industrial buildings. Would like engineering position, or sales engineering. C-8460.

ELECTRICAL ENGINEER, graduate, E. E. degree, 28, married. Three years' experience relays, relay studies of large electric power and light utility, operating, New York City. Three years testing, design, and development work on new electrical appliances and materials. Experience includes considerable outside contact with leading electrical manufacturers. Available immediately. Location, New York City. B-8793.

ELECTRICAL ENGINEER, American. Street railway, main-line electrification, mining, and public utilities. Twenty years in Latin America as engineer and manager. Did considerable Diesel-engine and refrigeration work. B-5912.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930, cooperative plan. Westinghouse lighting courses. Cooperative work, alternate months, five years in substation maintenance and office engineering. Rebuilding transformers, switches, lightning arresters, work with electric furnaces, rectifiers, meters, motors, etc. Checking and mapping distribution systems, work orders, drafting, etc. Excellent references. Perfect health. Location immaterial. C-7847.

EXPERIENCED ELECTRICAL ENGINEER, graduate of two colleges, with twenty years of accomplishment in the electrical wire and cable industry; American, Protestant, and in good health. Would prefer to locate within 100 mi. of New York, though not essential. Can come for interview promptly; all references desired. B-9877.

MECHANICAL-ELECTRICAL ENGINEER, 46, single, 23 years' experience. Factory test, central station engineering, and sales work. Public utility operating engineer, assistant superintendent, and superintendent of construction, power and electric departments. Estimate and design work on substations, stations, relay systems, and lines. Specifications for buildings. B-271.

ELECTRICAL ENGINEER, 48, college graduate, married; 26 years' experience as designing, report, power and executive engineer with three engineering and construction firms, including system planning, design, construction cost estimating and construction supervision of power plants, substations and transmission facilities for public utilities and industrials. Studies of operating economics. B-4558.

ELECTRICAL ENGINEER, 26, single. Three years' experience with construction company, specializing in new construction. One and a half years' experience in light current work with leading telegraph company. Desires connection with company in construction or sales engineering departments. Location, New York City preferred. C-9290.

EXECUTIVE ELECTRICAL ENGINEER, 29, married. Six years' experience in design, and construction of transmission lines and substations. Now district manager for electrical manufacturing concern. Desires to make change. Available immediately. Location, immaterial. C-9324-315-C-4-San Francisco.

COLLEGE TRAINED ENGINEER, 29, married. Experienced in the design and estimating of distribution systems. Nine years' utility experience in responsible position. One and a half years' power cable engineering. Desires position with New York City utility, engineering or industrial company. Excellent references. C-9361.

HEAD OF ENGINEERING DRAWING DEPARTMENT of prominent university for seven years, will consider change to similar position. Available June 1931. B. S. in electrical engineering. Telephone and electrical experience. Practical machine designer. B-8248.

ELECTRICAL ENGINEER, graduate of University of Illinois, 1926. Two years' experience with Westinghouse, and two and a half years with public utility in planning division. Available immediately. C-9381.

GRADUATE ELECTRICAL ENGINEER, 29, married. One year eight months, Westinghouse test. Two and a half years' electrical construction with utility, engineering, supervision and reports. One year three months with consulting engineers. Desires position in planning department of public utility. No preference in location. C-7695.

ENGINEER, age 27, B. S. three years and seven months C. E. experience, desires position with hydroelectric project. Qualified for chief of party, transitman, estimator, assistant engineer. C-9382.

GRADUATE ENGINEER, age 35, two years' shop experience, fourteen years as draftsman in design of mechanical and electrical apparatus. Graduate of mechanical and electrical engineering courses of International Correspondence Schools. Willing to accept drafting or engineering position anywhere. C-9387.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility, and industrial surveys covering cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense and cost analysis. Capable organizer. Profitable assistant for busy executive. Prefers East. Consider any proposition. B-9122.

COMMUNICATION ENGINEER, 31, single. Experienced: telephone, radio installations; design, development of testing equipment for telephone, radio, sound-picture circuits; design, use of semi- and full-automatic testing circuits to eliminate human element in testing; industrial applications of photoelectric cells, thermionic tubes. Best references as to professional ability, personal integrity. Location, immaterial. Available immediately. C-9376.

ELECTRICAL ENGINEER, age 29, married, Pennsylvania State graduate 1925, with four years' railroad and subway signal installation experience as engineer, draftsman, and signalman, and one and a half years as assistant project engineer on railroad electrification; desires position in either of these lines. Location, anywhere. C-5089.

A-C. DESIGN ENGINEER, induction, and synchronous motors above 20 hp., alternators and auto-transformers. Experienced in the application of synchronous motors to compressor drive. Married. Location, immaterial C-9386.

PHYSICIST, middle-aged, experienced in industrial research, supervision of research, executive work, and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent American universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available on short notice. C-7900.

ELECTRICAL ENGINEER, EXECUTIVE, FOREMAN, 25 years' sound practical, technical, electrical and mechanical manufacturing experience in telephone and telegraph apparatus, instruments, printing machines, and pressed metal. Capable organizer and supervisor. Works and office system, estimating, cost analysis and accounts. Methods, tool design, machine and press-work, time-study rate-setting, moderate salary. Any location. C-3241.

DESIGN ENGINEER, twenty years' experience in design of a-c. machines covering polyphase induction motors of all sizes. Single-phase induction motors with inductance or capacity starting. Single-phase commutator motors of series, repulsion, and repulsion-induction type. Desires design or development work. Location, immaterial. C-8540.

1931 GRADUATE ELECTRICAL ENGINEER, B. E. E. University of Minnesota. Single, age 22. Special courses taken include design, radio and telephone. Desires position with any manufacturing or engineering firm. Location immaterial, opportunities and experience being main factors. Available immediately. C-9391.

INDUSTRIAL PRODUCTION MAN, electrical engineer, married, age 29, good health, graduated 1924, seven years' experience with large construction company on design, engineering, and construction of power and industrial plants. Wants production department job where electrical training and experience will count, with possibility of working into management. Location, New England. C-9384.

ELECTRICAL OR MAINTENANCE ENGINEER, 48, married, college graduate, 22½ years with present employer. Plant sold to large organization with its own engineers. Unusual experience in installation and operation of industrial substations, large synchronous motors, replacing 25 with 60 cycles and maintenance. Good mechanical, steam and process development experience. C-9399.

ELECTRICAL ENGINEER, B. S. degree, married, with about fifteen years' successful experience in the design and construction of transmission and distribution lines. Some teaching experience. Employed at present. Desires position as instructor in electrical engineering subjects or physics and mathematics. Excellent references. Location preferred, Middle West or West. C-9339.

ELECTRICAL ENGINEER, 27, single, B. S. E. E. Six months Westinghouse Graduate Student Course. Two years' laboratory work circuit interrupters, large power rectifiers, one and a half years' development work on standard magnetic controllers for steel mill applications, handling negotiations, estimating on motor-control apparatus. Familiar French language. Available immediately. Location, preferably East. C-9393.

ELECTRICAL ENGINEER, 36, single, citizen, desires position with engineering, manufacturing, or public utility concern. Six and a half years' experience in power plant and substation design. Two years in electrical furnace work. Highest education. Additional G. E. engineering course. Speaks foreign languages. Available on short notice. C-2710.

1929 ELECTRICAL DESIGN ENGINEER, 24, B. S. degree technical school. One year Westinghouse Student Course. Motor, transformer, turbo test experience. One year large synchronous motor design. Six months Westinghouse electrical design school. Desires position, design, research, development work with manufacturing company, or engineering department power company. Single with dependents. Location, immaterial. References. Available immediately. C-9410.

GRADUATE ELECTRICAL ENGINEER, Lehigh University (1930), married, 25, ten months engineering graduate student at Westinghouse, 22 summer months with National Tube Company. Desires position with public utility or manufacturing company where analytical and research ability is prime prerequisite. Available on two weeks' notice. Location, East or Middle West. C-9395.

1931 ELECTRICAL GRADUATE, midwest university, 22, single. Tau Beta Pi student. Desires connection with manufacturing or public utility concern. Location preferred, Middle West. C-9398.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930, age 23, married, now employed by large industrial corporation. Desires position with public utilities or with small industrial, United States or foreign. Available on short notice. C-9396.

ELECTRICAL ENGINEER, 31, married, college graduate, with six and a half years' experience consisting of: oil circuit breaker design; electrification of industrial plants; operation, maintenance and electrification of ore mines and steel mills. Thoroughly experienced on motor applications, transformer stations, switchboards, and distribution systems. Last one and a half years as electrical engineer with steel company. C-9414.

ELECTRICAL ENGINEER, 30, married, A. B. '22, B. S. in E. E. '24 (Harvard). G. E. Test, transformer design, development and technical writing; experience in factory planning, has taught evening classes; speaks German. Location preferred, East. C-9402.

ELECTRICAL ENGINEER, draftsman, experienced designer of light and power layouts of generating substations (indoor and outdoor) office buildings, factories and air ports. Technical school graduate and fifteen years' practical experience in the electrical and mechanical industry. C-7979.

REPRESENTATIVE available. Experienced sales engineer, electrical engineer, graduate. Desires high-grade electrical line of utility or heavy-duty industrial equipment. Eastern location. B-4067.

ELECTRICAL ENGINEER, 36, university graduate, married. Twelve years with large public utility as cadet, inspector and electrical tester (motors, transformers, cables, and electrical appliances). Also one and a half years' research on combustion control apparatus for instrument manufacturer and some engineering sales experience. Desires position with future near Philadelphia. References. C-8350.

ELECTRICAL ENGINEER, 1928 graduate of a recognized university, 26, single. One year central station testing, twenty months special apprentice on a large electrified railroad and seven months' telephone experience. Seeks engineering position where the above training and experience can be applied, free to locate anywhere. C-9112.

GRADUATE ELECTRICAL ENGINEER, S. B. from M. I. T. in 1927. Accidental injury has prevented employment. Now recovered. Has done considerable study since graduation in electrical engineering and physics, particularly radio and acoustics. Interested in most any kind of connection. Available at once. Single, age 25. C-9205.

SALES ENGINEER, distinctly electrical background, has good sales record, profit-minded, 39, single, likes people and contacts. Seeks permanent connection with leading company manufacturing controls for industrial applications. Conversant with thermoelectric and photoelectric principles. Specialized knowledge of conductors. Decided interest in distribution in broadest sense. Has proved executive ability. C-8797.

TECHNICAL GRADUATE, 32, with broad experience in operation, maintenance of substations, cable network, electric shovels. Substation testing. Speaks five languages. Desires connection with responsible company. Location, immaterial. B-9611.

ELECTRICAL ENGINEER, 36, married, 18 years' experience on power plants, transmission lines, substations, switchboards. Telephones, mine electrical equipment, motors, lighting, marine electrical work, draftsman. Five years electrical engineer wiring for power, light, telephones, signal systems, elevators for all types of buildings; also expert plumber, heater and tinner. C-9348.

GRADUATE ELECTRICAL ENGINEER, married, age 27, one year Westinghouse Student Course, two years' production control; two years' maintenance engineering. Desires permanent position with future. Will consider anything. Location, immaterial. C-9425.

GRADUATE ELECTRICAL ENGINEER, 1929, 22, single; 15 months on General Electric Test Course. Desires position with utility or manufacturing company or with concern doing consulting or construction engineering. Available immediately. Location, New England preferred. C-8028.

1931 GRADUATE ENGINEER, single, age 23. B. S. in E. E. from Lafayette College. Ten months' experience as assistant engineer with large belting company. Three months radio coil test. Prefers engineering position with engineering company or manufacturing company. Best of references. Location, immaterial. Available immediately. Slight knowledge of Spanish. C-9422.

GRADUATE ELECTRICAL ENGINEER, B. E. E. degree, 1930, 24, single; eight months on Westinghouse course. Assignments covered motor apparatus testing and refrigeration development work. Desires position with manufacturing concern or public utility. Working knowledge of Spanish. Initial salary and location secondary to opportunity. Reference. Available on short notice. C-9428.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with eight years' experience in industrial plant construction and maintenance; railway electrification; power-plant design, estimating, and construction. Supervisory experience on construction and costs with contractor. Desires position with utility, manufacturer, or contractor, where ability to handle labor and produce results is a prerequisite. C-4428.

RECENT GRADUATE, 23, Pratt Institute in Industrial electrical engineering. Four years' practical experience in installation work and operation of substations. Specialized in motor control. Desires position with power company or related work in manufacturing or construction. Location, immaterial. C-9176.

ELECTRICAL-MECHANICAL ENGINEER, married, seven years' experience including G. E. Test, substation, and distribution with utility, development with electrical manufacturer, superintendent of small shop and operation of substations and motor rooms with a steel mill. C-1068.

MOTOR DESIGNER, graduate electrical engineer, 33, married, experienced in design of a-c. and d-c. motors and generators. Available immediately. C-8553.

ELECTRICAL ENGINEER, 27, Italian, M. S. Harvard University, Dr. Eng. University of Rome, exceptional theoretical and research grounding, five years' experience best firms electrical communication in Italy, United States America, Germany, England. Desires position for design or research work in Europe, England or continent. C-9431.

ELECTRICAL ENGINEERING TEACHER, B. S. and M. S. in E. E., G. E. Test, eleven years' teaching experience with recognized technical school. Desires permanent position. Available September. Excellent references. Age 36. C-5807.

ELECTRICAL ENGINEER with fifteen years' experience in design, construction, reports and editorial work. Available for publicity or editorial work on trade publications. References with leading engineering and publishing firms can be furnished. B-4022.

ELECTRICAL ENGINEER, technical college graduate, age 35. Ten to twelve years' mechanical and electrical experience in power plants, substations, transmission and distribution systems. Work includes G. E. Test and public utility engineering and operation. Desires position on operating staff of power company. Location, not particular. B-9732.

GRADUATE ELECTRICAL ENGINEER, 46. Eighteen years' experience in the manufacture of electrical wiring devices, including designing, development, testing, estimating, cost and production work. Four years with underwriters' laboratories in charge of a branch office making inspections, tests, examinations, and reports. Desires position with manufacturing concern, inspection bureau or experimental laboratory. C-8449.

ELECTRICAL ENGINEER, 37, single, B. Sc. Eng. London University 1920. Six years with British Thomson-Houston Company. Two years with power company in Pennsylvania. Three years with General Electric Company. Five years war service. Available at once. Any location. C-2248.

ELECTRICAL ENGINEER, one year's experience test course. Three years' experience transmission engineering department of large eastern electrical manufacturer. Desires position with utility company, teaching. Thoroughly familiar power system short-circuit, stability analyses, theory, application of method of symmetrical components. B. S. E. E. University of California 1927, 24, married. Available July first. C-9437.

ELECTRICAL ENGINEER, B. S. in E. E., age 30, married. Manufacturing and test experience. Public utility transmission and distribution engineering experience. Sales experience. Executive and teaching ability. Salary expected, open to offer. Position desired, open to offer. Available at once. C-7867.

ELECTRICAL ENGINEER, 28, married, four years out. One year power utility course, three years telephone and talking pictures. Previous experience as commercial radio operator. Would be valuable to concern requiring capable engineer. Position must be permanent with future. Location not a guiding factor. Best of references are available. C-7902.

ELECTRICAL ENGINEER, 30, married, graduate 1924. Two years' postgraduate work, advanced electrical theory, two and a half years' writing specifications for the manufacture and installation of telephone repeater offices, one year at generator design and two years as field engineer for public utility. Desires position with future. C-951.

ELECTRICAL ENGINEER, B. S. in E. E., single, age 27. Five years' experience with electrical manufacturer on the development, design, and application of lightning arresters. Also close contact with lightning field investigations of recent years; familiar with this work and its results. Position with operating company preferred. C-9449.

TEACHER OF ELECTRICAL ENGINEERING, 37; married. Thirteen years' teaching experience; many summers spent in practical work. B. S. in E. E. and E. E. degrees. Taught all electrical engineering subjects as well as physics, electric thermodynamics, descriptive geometry, mechanical drawing. Sixteen months' general management large college radio station. Available immediately. C-9445.

ELECTRICAL ENGINEER, E. E. graduate 1924, age 29, married. One year telephone maintenance, two years General Electric Test, one year research, four years system operator large public utility. Experienced radio installation and maintenance. Desires position along line of experience with advancement opportunities. Location preferred, vicinity of greater New York. Available now. C-4182.

ELECTRICAL ENGINEER, 22, single, university graduate '31. Desires junior position in test or design departments of power machinery manufacturing concern. Experience limited. Location preferred, East. Available on short notice. C-9447.

ELECTRICAL ENGINEER, graduate 1931, single. Three years' cooperative experience in public utility maintenance work. Four summers' experience in ice-cream industry. Desires opening offering steady work and possibility of advancement. Location and type of work secondary. Available at once. C-9418.

ELECTRICAL ENGINEER, class '31, from a southern technical institute desires a part or full-time position as instructor in mathematics or electrical engineering with the privilege of carrying graduate work. C-9415.

1931 GRADUATE ELECTRICAL ENGINEER, age 26, industrious, reliable, Russian and American education seeks permanent connection. Location, immaterial. C-9455.

ELECTRICAL ENGINEER, 43, married, twenty years' electrical, power, and industrial plants experience in construction, maintenance of distribution, and transmission lines. Desires position with public utility or industrial plant. Can qualify as electrical superintendent. Used to handling men. Available on short notice. Canada preferred but would consider other location. C-9459.

ELECTRICAL ENGINEER, B. S. E. E. '30, age 22, single. One year General Electric Test. Desires position in either sales or operating department of public utility, or in any electrical line offering a future. Location, immaterial. Available at once. C-9454.

GRADUATE IN ELECTRICAL ENGINEERING, 1931, age 26, single, has B. S. in E. E. One year of electrical testing with large utility company. One year of electrical drafting of power and control switchboards. Three years' work in practical electricity. Interested in construction and supervision of small plants. Available at once. Location, anywhere. C-9457.

JUNIOR ENGINEER, 1931 graduate, B. S. E. E., University of Alabama. Desires position with utility, construction, manufacturing company. Location, immaterial. Experienced in power-plant and building installation and industrial control, having been employed for eight summer months and one full year, first as electrician helper and later as first-class electrician. C-9446.

RAILROAD ELECTRICAL ENGINEER, college graduate; A. I. E. E., A. S. M. E. A. E. R. A., A. R. A. membership; six years' design, construction, and operating experience on two large American railroad electrifications; familiar with American and European practises regarding motive power, substations, catenary, transmission lines. Excellent references; young. Desires position with consulting firm, railroad, power company, or manufacturer. C-8463.

GRADUATE in electrical engineering, class of '29, 25 and single; fourteen months G. E. Test. Four months' experience in research. Desires position in engineering department of utility or manufacturing company offering a future. Available at once. Location, eastern United States. C-9003.

ELECTRICAL ENGINEER, 32, technical graduate, twelve years' experience with public utilities; familiar with operation, design and construction of transmission lines, substations, steam and hydro-generating stations. Familiar with field and office work. Desires responsible position with holding company, operating company or consulting engineer. Location, immaterial. Available immediately. C-6401.

ELECTRICAL ENGINEER, 36, married, technically trained, fifteen years' experience covering complete engineering design, supervision of power plants, high-voltage switching stations, substations, transmission lines, including estimates, specifications, purchase of equipment, supervision of construction. Experience covers system development, investigations of systems for load conditions, expansion, relay and stability studies, frequency and load control. C-7194.

ELECTRICAL ENGINEER, E. E. from European electrotechnical university, M. S. from University of Michigan; 9 years' experience with public utilities in construction, maintenance, and design; three years with Westinghouse switchboard department, including engineering school; desires position of designing engineer with public utility or large industrial concern. C-4976.

ELECTRICAL ENGINEER, 22, single. E. E. degrees, 1929; M. S. in E. E. from M. I. T., 1931; 20 months' General Electric Test course. Desires position involving electric design and development or as instructor in electrical engineering. Location preferred, East. Available immediately. C-9462.

JUNIOR ENGINEER, 1930 graduate, B. S. degree in E. E., associate member of Sigma Xi. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

SALES ENGINEER, 36, married, graduate electrical engineer, fifteen years' experience, includes sale signal and telephone apparatus, control and charging equipment, light machinery and its design. Also field supervision, organizing, technical writing, engineering building projects, layouts, specification writing, estimating, teaching, lecturing. Available within two weeks. Location, vicinity New York City. B-247.

ELECTRICAL, STEAM, AND MECHANICAL SUPERVISOR, 33, married, twelve years' experience in industrial and power plants. For the past four years has had charge of all steam and electrical power and maintenance of large industrial plant consuming 4,000 kw. and 1,200 hp. steam. B-7004.

GRADUATE ELECTRICAL ENGINEER, 30, married. Seven years' practical experience in design and construction of substations, electric distribution both overhead and underground, with relay application, industrial power layout, lighting design, familiar with the latest developments in these lines. Available immediately. B-6384.

ELECTRICAL ENGINEER, bachelor and master degrees; fourteen years' peculiarly broad experience in test, research and development, standardization, consultation, university teaching, executive work, personnel; familiar with both power and radio equipment and practise. Stability and opportunity primary; initial salary and location secondary. Available at once. C-4591.

COLLEGE GRADUATE, 27, single, B. S. in E. E. Eighteen months General Electric Test, 22 months telephone equipment engineer. Desires position in manufacturing or utility company. Location preferred, Middle West; however, not essential. Available at once. C-9285.

Membership

Recommended for Transfer

The board of examiners, at its meeting of June 5, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

MOWBRAY, WILLIAM J., cons. elec. engr., Cranston, R. I.

WELLER, GEORGE L., equip. and bldgs. engr., The Chesapeake & Potomac Tel. Co., Washington, D. C.

To Grade of Member

ASHMORE, JOSEPH, dist. mgr., British Elec. Repairs, Ltd., Birmingham, Eng.

BIEGEL, EARL J., asst. supt. elec. dist., Memphis Pwr. & Lt. Co., Memphis, Tenn.

BOROKHOVICH, JOHN A., asst. engr., Brooklyn Edison Co., Brooklyn, N. Y.

CLARK, EDWIN E., asst. prof. of elec. engg., South Dakota State School of Mines, Rapid City, S. D.

EVERITT, WILLIAM L., assoc. prof. elec. engg., Ohio State University, Columbus, Ohio.

GRAHAM, ROBERT W., asst. elec. supt., Bethlehem Steel Co., Buffalo, N. Y.

GRISCOM, SAMUEL B., central sta. engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

HAINES, THOMAS H., supt. maint. of lines dept., Edison Elec. Illuminating Co. of Boston, Mass.

HARTMAN, HOWARD W., design engr., General Elec. Co., Schenectady, N. Y.

HELLERN, BERNHARD, production engr., National Industri, Drammen, Norway.

JONES, EVAN R., transm. engr., Mountain States Tel. & Tel. Co., Denver, Colo.

KAIGHN, HERBERT E., cons. engr., Wilmington, Del.

KLEIN, HARRY R., JR., engr., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

LAKE, MARSHALL E., pwr. sales engr., Duke Power Co., Charlotte, N. C.

MIER, C. WALKER, engr., Southwestern Bell Tel. Co., Oklahoma City, Okla.

MILBURN, LOYAL B., asst. elec. engr., Great Lakes Steel Corp., Detroit, Michigan.

MOREHOUSE, ADEN K., toll service supervisor, Pacific Tel. & Tel. Co., Portland, Ore.

OVERROCKER, RANDALL H., asst. engr., New Jersey Bell Tel. Co., Newark, N. J.

PURDY, HARRY E., engg. asst., Brooklyn Edison Co., Brooklyn, N. Y.

SPOONER, HOWARD M., field engr., United Engineers and Constructors, Inc., Newark, N. J.

STEBBINS, FREDERICK O., engr., General Elec. Co., Schenectady, N. Y.

YERKES, EARLE P., engineer of equipment, Bell Telephone Co. of Pa., Philadelphia, Pa.

YOUNG, HADLEY E., supt., East Canada Creek Hydro Sta., New York Power & Light Corp., Little Falls, N. Y.

ZEBLEY, JUNE S., supervisor of inspectors, Elec. Dept., Dist. of Columbia, Washington, D. C.

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before July 31, 1931.

Balliett, C. G., Rochester Telephone Corp., Rochester, N. Y.

Balmford, J. A. (Member) Columbia University, New York, N. Y.

Barksdale, G. R. (Fellow) Tennessee Electric Power Co., Chattanooga, Tenn.

Brobson, J. F., Detroit Daily Mirror, Detroit, Michigan

Bulkley, O. R., Southern California Edison Co., Long Beach, Calif.

Clark, J. H., Southern California Telephone Co., Los Angeles, Calif.

Cline, J. E., Southern Indiana Tel. & Tel. Co., Seymour, Indiana

Eliason, W. L., Ontario Paper Co., Ltd., Thorald, Ont., Canada

Ennis, A. G., Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.

Finfer, Sidney, Police Department, City of New York, New York City, New York

Finley, R. F., New York Central Lines, New York, N. Y.

Foernsler, L. O., 11113-113th St., Richmond Hill, N. Y.

Gray, L T., Jr., Pacific Gas & Electric Co., San Francisco, Calif.

Hansen, F. A. (Member) Holophane Co., Inc., Los Angeles, Calif.

Hery, V. D., Index Machinery Corporation, Cincinnati, Ohio

Karle, J. J., Kny-Scheerer Corp., Long Island City, N. Y.

King, C. J., Montaup Electric Co., Somerset, Mass.

Korik, C. (Member) Home Engineering Co., Philadelphia, Pa.

Lee, A. C. (Member) Duke Construction Company, Durham, N. C.

Long, W. F., Union Electric Light & Power Co., St. Louis, Mo.

Mallory, D. D., Valparaiso University, Valparaiso, Indiana

Miller, T. H., 1575 Washington Street, San Francisco, Calif.

Mitchell, I. A., Kenyon Transformer Co., Inc., New York, N. Y.

Mowry, C. H., The New York Telephone Co., Brooklyn, New York

Murray, J. S. (Member) Follansbee Brothers Co., Follansbee, W. Va.

Neuschot, R. (Member) Thompson-Starrett Co., Inc., New York City, N. Y.

Nicol, W. C., Hartford Steam Boiler Inspection & Insurance Co., Chicago, Ill.

O'Handley, J. A., Western Electric Co., Kearny, N. J.

Rathbun, V. R., Dept. of Public Utilities, Tacoma, Wash.

Reynolds, F. N. (Member) General Electric Co., Philadelphia, Pa.

Robinson, F. W., Stanton Oper. Co., Pittston, Pa.

Ruddell, L., Kansas City Power & Light Co., Kansas City, Mo.

Schwabacher, G. P., General Electric Co., Bridgeport, Conn.

Seaman, F. D., Dominion Electric Power Ltd., Regina, Sask., Can.

Smith, C. C., General Electric Co., Bridgeport, Conn.

Steates, E. F., 11 Clark Place, Utica, New York

Stevens, O. L. Erie County Electric Co., Erie, Pa.

Stillwell, W. E., Jr., Union Gas & Electric Co., Cincinnati, Ohio

Stone, R. D., State Trade School, Willimantic, Conn.

Stretch, M. W., Westinghouse Elec. & Mfg. Co., Mansfield, Ohio

Thomson, G. T., Hydro Electric Power Commission of Ont., Leaside, Ontario, Canada

Van Horne, J. C., Powell, Wyoming

Wannag, V. E., Western Electric Co., Kearny, N. J.

Welch, W. M., Bell Telephone Co. of Penna., Philadelphia, Pa.

Wold, T., Smith & Stone, Ltd., Georgetown, Ont., Canada

45 Domestic

Foreign

Barnes, H. W., Ferranti Ltd., Aldwych, London, Eng.

Ganpathi, R., The Cochin Electric Co. Ltd., Cochin, South India

Cheryan, P. C., Siemens-Schuchert-Werke A. G., Berlin, Germany

Phillips, F. A., Electrical & Radio Service Co., Hurstville, Australia

Ram, A., Renala Hydro Electric Installation, Renala Khurd, Dist. Montgomery, Punjab, India

Roth, A., Kabelfabrik und Drahtindustrie Aktien-Gesellschaft, Vienna, Austria

Shinohara, K., Ministry of Communication, Tokyo, Japan

Taylor, M. G., c/o Venezuela Power Co., Ltd., Barquisimeto, Venezuela, S. America

8 Foreign

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during May are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

FACHAUSDRÜCKE DER SCHWEISSTECHNIK. Deutsch-Englisch-Russisch. Berlin, V. D. I. Verlag, 1931. 31 pp., 6 x 4 in., paper, 2-r. m.——This little dictionary is intended to supplement the general engineering dictionaries by providing a list of the welding terms in general use, especially those of recent coinage. The book has been compiled by the welding committee of the German Engineering Society and is unusually successful in providing exact equivalents for the terms.

MACMILLAN TABLE SLIDE RULE. By J. P. Ballantine. N. Y., Macmillan Co., 1931. Tables, 11 x 9 in., paper, $.50.——A set of four numerical tables and four slides, by means of which the arithmetic problems that arise in trigonometry and engineering may be solved without calculation. The charts answer the purpose of an ordinary slide rule. Three to four places can be read direct; five or more may be had by interpolation.

RECORDING SOUND FOR MOTION PICTURES. Edit. by Lester Cowan for the Academy of Motion Picture Arts and Sciences. N. Y., McGraw-Hill Book Co., 1931. 404 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth. $5.00.——A textbook upon the technique of making sound pictures, prepared by a number of experts. The equipment for recording and reproducing sound is described in detail, as are also the manipulation of the film and the problems of studio acoustics and of recording. The book is the first to present a systematic account of practise in its field.

MECHANICAL LABORATORY METHODS. 4th edit. By J. C. Smallwood and F. W. Keator. N. Y., D. Van Nostrand Co., 1931. 386 pp., illus., diagrs., charts, tables, 10 x 6 in., cloth, $3.50.——Directions are given for testing and calibrating scales, calorimeters, brakes, fluid meters and other instruments, for analyzing fuels and determining their heat value, and for testing engines, boilers, pumps, refrigerating machinery, lubricants and electrical machinery. The principles underlying the methods are given, and the directions are clear and concise. This edition has been revised and rearranged to conform with modern requirements.

SPONS' ELECTRICAL POCKET-BOOK. By W. H. Molesworth. Lond., E. & F. N. Spon; N. Y., Spon & Chamberlain. 4th edit., 1931. 401 pp., diagrs., charts, tables, 7 x 4 in., leather, $2.50.——Small enough to be carried in a coat pocket, this work of some 400 pages contains a careful selection of material frequently needed for reference by engineers, particularly those engaged in central station work, transmission and railroading.

Theory and Practice of RADIO FREQUENCY MEASUREMENTS. 2nd edit. By E. B. Moullin. Lond., Charles Griffin & Co., Ltd.; Phila., J. B. Lippincott Co., 1931. 487 pp., illus., charts, diagrs., tables, 9 x 6 in., cloth. $12.50.——A practical laboratory guide covering all the measurements usually made and giving clear, detailed methods for making them. The new edition has been almost doubled in size and largely rewritten.

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(July 1931) Number	Author	Title
☐ 31-4	L. V. Bewley	Traveling Waves on Transmission Systems
☐ 31-9	J. J. Torok	An Experimental Lightning Protector for Insulators
☐ 31-10	R. R. Pittman and J. J. Torok	Lightning Investigation on a Wood Pole Transmission Line
☐ 31-20	Philip Sporn	1929 Lightning Experience on the 132-Kv. Transmission Lines of the Am. Gas and Elec. Co.
☐ 31-42	J. C. Dowell	Attenuation and Successive Reflections of Traveling Waves
☐ 31-57	F. A. Cowan	Recent Developments in the Operation of Overseas Radio Telephone Service
☐ 31-79	Philip Sporn and W. L. Lloyd, Jr.	1930 Lightning Investigations on the Transmission System of the Am. Gas and Elec. Co.
☐ 31-82	C. L. Fortescue and R. N. Conwell	Lightning Discharges and Line Protective Measures
☐ 31-85	Otto Brune and J. R. Eaton	Experimental Studies in the Propagation of Lightning Surges on Transmission Lines
☐ 31-86	I. W. Gross and J. H. Cox	Lightning Investigation on the Appalachian Elec. Pwr. Co.'s Transmission System
☐ 31-87	W. W. Lewis and C. M. Foust	Lightning Investigation on Transmission Lines—II
☐ 31-88	F. W. Peek, Jr.	Lightning, Characteristics—Induced Voltages—Direct Strokes—Coordination—Transmission Line Design
☐ 31-89	Edgar Bell and A. L. Price	Lightning Investigation on the 220-Kv. System of the Penn. Pwr. & Lt. Co. (1930)

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its publication in ELECTRICAL ENGINEERING. Thereafter charge of twenty-five cents per complete copy will btain.

Name..

Address...

Please order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Ammeters

HIGH FREQUENCY. A Method of Comparing Ammeters At Very High Frequencies, C. L. Fortescue and L. A. Moxon. *Sci. Instruments—Jl.*, vol. 8, no. 3, Mar. 1931, pp. 94-97, 5 figs. Considerable difficulty has been experienced in comparing ammeters at frequencies above one million cycles per second with reasonable degree of accuracy; means of overcoming these difficulties are described and final arrangement is reliable up to frequencies of 100 million to within accuracy of 2 per cent.

Brushes

COMMUTATOR. Double Brush-Holders Improve D-C. Machine Operation, A. M. Harrison. *Power*, vol. 73, no. 15, Apr. 14, 1931, pp. 586-587, 3 figs. Under certain conditions use of double brush-holders on d-c. machines is advantageous, while on other machines they may be objectionable.

Cables

PAPER INSULATED. The Manufacture of Lead-Covered Paper-Insulated Telephone Cable, J. R. Shea. *Mech. Eng.*, vol. 53, no. 4, Apr. 1931, pp. 277-283, 17 figs. Particulars regarding new developments comprising direct application of wood-pulp insulation, improved cable stranding, vacuum drying, and central melting of large quantities of lead alloy and its distribution through piping to number of sheathing presses. Before "Three-M" (Management, Materials, Maintenance) Congress, Cleveland, Ohio.

RUBBER INSULATED. Ueber Maschinen zur Herstellung von Kabeln (Machines for Manufacture of Cables), M. Pollman. *Gummi-Zeitung*, vol. 45, nos. 21 and 22, Feb. 20, 1931, pp. 876-877 and Feb. 27, pp. 914-916, 7 figs. Particulars of so-called wire-covering machines of both vertical and horizontal type for covering of thin and thick conductors. See reference to previous articles by author in same journal, in Engineering Index 1930, p. 545, and Engineering Index 1929, p. 603.

SUBMARINE. Some Economic Factors in the Design of Single Core Submarine Cables for Carrier Telephony, J. R. Vezey. *Elec. Communication*, vol. 9, no. 4, Apr. 1931, pp. 217-221, 4 figs. Having decided on length, attenuation, and number of speech channels for any cable, relative proportions of weights of central conductor, dielectric and return conductor to obtain lowest cost can be varied over wide range; further feature, brought out by study, is that maximum length of cable over which it is possible to work fixed number of channels, varies relatively little within limits of practical sizes of core.

TELEPHONE. Buried Tape-Armored Exchange Cable, C. W. Nystrom. *Telephony*, vol. 100, no. 14, Apr. 4, 1931, pp. 22-25, 10 figs. New method of underground exchange construction applicable to suburban residential areas; method and materials used in burying tape-armored exchange cable; cable placed in either hand or machine-dug trench.

Circuits

HIGH-VOLTAGE. A Note on the Timing of Electrically Independent Transient Circuits for High-Speed Oscillographic Work, L. B. Snoddy and J. C. Street. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 258-259, 3 figs. Method for initiating discharge in high-voltage circuits at definite time has been developed and applied to lightning generator voltages up to 430 kv.; method uses combination of over-voltage and irradiation by ultra-violet light; it has advantage that it requires no electrical connection between tripping circuit and high-voltage side of impulse circuit.

Circuit Breakers

ELECTRIC. Oil-Less Switchgear. *Elecn. (Lond.)*, vol. 106, no. 2760, Apr. 24, 1931, pp. 611-612, 3 figs. Siemens-Schuckert works and A. E. G. have, as result of experimental work in their laboratories, put on to market high capacity oil-less switches, thus showing their confidence in methods by which they have tackled problem; switches of both these types were on view at Leipzig Technical Fair.

Conductivity

The Electrical Conductivity of Some Bismuth Alloys at Low Temperatures, J. C. McLennan, J. F. Allen and J. O. Wilhelm. *Roy. Soc. Canada—Trans.*, vol. 24, pt. 1, section 3, May 1930, pp. 25-32, 1 fig. Investigation to find how superconducting point of lead would be affected by alloying this metal with bismuth and with antimony; also to determine superconducting point of some of fusible alloys of which bismuth is constituent. Bibliography.

Control

CHEMICAL PLANTS. Centralized Control Improved Production, A. J. A. Peterson, *Instruments*, vol. 4, no. 2, Feb. 1931, pp. 51-53, 2 figs. Large chemical plant in Niagara Falls applied to its problem of machine and load control, same principles used in central station industry; in this plant, operator must control and supervise 10 to 14 manufacturing units, all forming heavy electrical loads, and must supervise incoming supply as well.

ELECTRIC HEATING. Radiation-heating Control, C. G. Heys Hallett. *Elec. Rev.*, vol. 108, no. 2785, Apr. 10, 1931, pp. 626-627, 4 figs. Remarkable economies in current consumption and gains in personal comfort result from use of radiation thermostat or "Eupatheostat" as compared with ordinary air thermostat.

Controllers

Misapplications of Control Equipment, H. C. Jenks. *Indus. Eng.*, vol. 89, no. 3, Mar. 1931, pp. 110-113, 4 figs. Putting control equipment in service for which it was not designed frequently causes trouble; practical discussion of control equipment breakdown and methods of prevention.

Currents

HAZARDS. Note sur la tension non dangereuse des courants électriques (Safe Voltages of Electric Currents), Feraud. *Société Francaise des Electriciens—Bul.*, vol. 1, no. 3, Mar. 1931, pp. 288-301 and (discussion) 302-305. Qualitative definition of safe voltages; influence of characteristics of source on hazards, influence of outside circumstances at source on hazards; dangerous current; quantitative analysis of safe voltages; conclusions.

Dielectrics

X-RAY ANALYSIS. X-Ray Studies of Motions of Molecules in Dielectrics Under Electric Stress, R. D. Bennett. *Franklin Inst.—Jl.*, vol. 211, no. 4, Apr. 1931, pp. 481-487, 7 figs. Experiments at Ryerson Physical Laboratory lead to conclusion that molecular group state of liquid is accentuated as liquid solidifies leading to definite crystalline structure, which can be strongly oriented by electric field; it is concluded that X-ray methods may prove useful tool in investigation of molecular motions in dielectrics.

Electricity

Electricity—What It Is and How It Acts—L, A. W. Kramer. *Power Plant Eng.*, vol. 35, no. 9, May 1, 1931, pp. 514-516. Electron and proton as factors in explaining radiation from sun and stars.

Electric Drive

BLOOMING MILLS. 5000 Hp. D-C. Motor Drives New Algoma Rail and Structural Mill, A. F. Kenyon, *Elec. News*, vol. 40, no. 7, Apr. 1, 1931, pp. 54-56, 4 figs. Demands of Canadian railways for longer and heavier steel rails has necessitated complete rebuilding and electrification of the rail and structural mill of Algoma Steel Corporation, Sault Ste. Marie, Ont.; initial rolling of 26 in. x 26 in.—13,500 lb. ingots is in electrically driven 35 in. reversing blooming mill, ingots being reduced to 10 in. x 10 in. and smaller blooms, depending upon product being rolled in finishing mills.

PAPER AND PULP MILLS. New Mill Drive at Smith Paper Co. Aids Heat Balance, R. A. Packard. *Power*, vol. 73, no. 13, Mar. 31, 1931, pp. 504-506, 6 figs. Synchronous motor on turbine shaft permits unit to be governed by low-pressure steam demand; surplus or efficiency of power being taken by utility system; diagram of steam distribution at Columbia mill; diagram of main electrical connections.

PUMPS. Selecting the Motor to Suit the Pump, E. C. Dieffenbach. *Power*, vol. 73, no. 17, Apr. 28, 1931, pp. 656-659, 6 figs. Starting conditions and nature of various loads determine motor and control; to choose wisely, both motor and pump characteristics must be understood; drives for reciprocating, centrifugal, rotary and screw pumps are discussed; characteristic curves.

ROLLING MILLS. Modernizing Rolling Mills Electrically. *Iron and Steel Industry*, vol. 4, no. 7, Apr. 1931, pp. 235-238, 4 figs. Examples of modern main drives for rolling mills carried out by English Electric Co.; sheet-mill and merchant-mill drive; large motor for Brown Bayley and Co.; exciter set for mill motor; strip mills and cold-roll drives; heating of sheet-mill rolls; special tube-mill installation; frequency standardization; switchgear.

WIRE DRAWING MACHINES. Electric Equipment for Wire Drawing, T. R. Rhea. *Wire*, vol. 6, no. 5, May 1931, pp. 165-167-170 and 185, 8 figs. Various types of machines and type of motors and control which experience has determined as most suitable.

Electric Equipment

AUTOMOBILES. Modern Electric Equipment of Motor Vehicles, V. A. Karpov. *Electritchestvo*, no. 2, Feb. 1931, pp. 69-76, 10 figs. Systematic review of electric equipment of motor cars, tractors, and motorcycles; typical schemes of electric equipment for modern motor vehicles of different systems applied in U.S.S.R. and other countries; power-supply systems and electric accessories are critically described. (In Russian.)

MAINTENANCE AND REPAIR. Maintenance Methods for Electrical Equipment, E. L. Richards. *Power Plant Eng.*, vol. 35, no. 6, Mar. 15, 1931, pp. 360-362, 3 figs. Systematic maintenance schedule insures against shutdowns and anticipates repair work; importance of inspection schedule and records; maintenance record forms.

Electric Lines

HIGH TENSION DESIGN. Design of 110- and 132 Kilovolt Steel Tower Transmission Lines. *Nat. Elec. Light Assn.—Report*, no. 17, Mar. 1931, 16 pp., 3 figs. Condensed discussion of more important factors entering into design of 110- and 132-kv. steel tower transmission lines showing what items enter into transmission line specification together with some indication of typical practise with respect to each item, *i. e.*, location, electrical clearances, conductors, tower loading, transmission tower specifications; insulation; telephone lines.

PROTECTION. Protection of Rural Lines. *Elecn. (Lond.)*, vol. 106, no. 2760, Apr. 24, 1931, p. 610. Discussion by Overhead Lines Association on control and protection of rural lines; standard nomenclature is needed; oil and air break switches compared. Before Instn. Elec. Engrs.

Electric Power

RAYON PLANTS. Electrification of a Rayon Mill. *Elec. Times*, vol. 79, no. 2055, Mar. 12, 1931, pp. 473-475, 6 figs. Power generation and distribution in Sunsheen's Mills, Ballymena, Ireland, with special reference to problem of cabling and wiring; current is generated by means of two steam-driven turbine-generators, main unit of 820-kw. output, at 400 volt, 50 cycle, three-phase, neutral point being brought out, so as to provide 230 volts for lighting; second turbine set is of 100 kw.; steam is raised in three Lancashire boilers 8 ft. by 30 ft., working at 180-lb. pressure and superheated 150 deg. fahr.

Electric Towers

TESTING. Testing Full-Size Transmission Towers, N. B. Obbard. *Eng. News-Rec.*, vol. 106, no 18, Apr. 30, 1931, pp. 735-737, 4 figs. Description of plant of American Bridge

Co., in Pittsburgh, equipped to test towers up to 100 ft. in height, either on fixed grillage or on their own earth anchors; wind and conductor loads applied simultaneously at as many as seven points by pulling rig actuated by 50,000-lb. mechanical screw.

Electrodes

POTENTIALS. The Nernst Equation—A New Equation for Electrode Potentials—1, M. Meyer. *Chem. News*, vol. 142, no. 3701, Mar. 20, 1931, pp. 179-183, 2 figs. Many corrections have been applied to concentration of "active" material in effort to secure better agreement; all save "activity" coefficient fail; textbooks still make curious comments about equation; since electromotive force measurements may be made with great precision it may be of interest to examine some and also another possible equation which, however, because of its nature, seems only of academic interest.

Engineering

BUSINESS RELATIONS. Shall We Revise Our Conceptions of Engineering Functions, L. E. Jermy, *Machine Design*, vol. 3, no. 5, May 1931, pp. 23-25, 2 figs. Study of relationship and responsibilities of engineer to principal departments of industrial organization; chart illustrates relationships of chief engineer.

EDUCATION. A Suggestion for Engineering Education, L. E. Moore, *Boston Soc. Civil Engrs.—Jl.*, vol. 18, No. 4, Apr. 1931, pp. 95-102. Development of engineering education; engineering specialties; search for school to meet ideals for training; suggested course for students in engineering, natural philosophy, and sciences; author criticizes existing system for turning out men who are too often narrow technicians instead of scientifically educated gentlemen, capable of taking hold of any branches of applied science and by study specializing in them.

INFLUENCE ON CIVILIZATION. Technology and Material Progress, W. R. Whitney, *Science*, vol. 73, no. 1877, May 8, 1931, pp. 483-486. It is claimed that accumulated data of all material progress never were so great and never so uniformly appreciated; those who are interested in technical progress look at it as continuous, but do not necessarily overrate its importance; there must be parallel advance for higher values in man. Before Am. Philosophical Soc.

Engineers

RESPONSIBILITY. The Responsibility of the Engineer, R. V. Wright. *Engrs. and Eng.*, vol. 48, no. 4, Apr. 1931, pp. 73-75. Economist as well as engineer has been sticking too much to cold facts and seems to have overlooked fact that most precious factor in industry, human element, must be handled in entirely different way from materials and natural forces; now great problem of engineer is to deal with human life in industry. Before Engrs. Club.

Exciters

TURBO-GENERATORS. Turbo-Generator Exciters, W. Sharp. *Elec. Times*, vol. 79, no. 2059, Apr. 9, 1931, pp. 659-660, 6 figs. Probable lines of progress and subsequent developments in connection with manufacture of turbo-generator exciters; subject as direct bearing upon possibility and advisability of making continuous-current exciter remote from turbo-generator.

Furnaces

ANNEALING. Electric Annealing of Aluminum. *Foundry Trade Jl.*, vol. 44. no. 763, Apr. 2, 1931, p. 244, 1 fig.; see also *Metal Industry (Lond.)*, vol. 38, no. 14, Apr. 3, 1931, p. 364, 3 figs. and *Mech. World*, vol. 89, no. 2310, Apr. 10, 1931, p. 343. To facilitate precise annealing of aluminum sheets on large scale, General Electric Co., has installed large single-track multi-car type electric annealing furnace which has effective hearth area 24 ft. long by 7 ft. 5 in. wide in works of Aluminum Corp., Dolgarrog, Carnarvonshire; furnace has electric loading of 150 kw., heating elements arranged to ensure phasal balance on 440-volt, 3-phase, 50-cycle supply.

HEAT TREATING. Bright Anneals in Artificial Atmospheres, J. C. Woodson. *Elec. Jl.*, vol. 38, no. 4, Apr. 1931, pp. 246-247, 3 figs. Possibilities of annealing in artificial atmospheres, which process is still in development stages, are not known; however, certain surface conditions can be obtained that reduce number of subsequent operations and greatly increase die life and reduce machine work; various types of electric furnaces are illustrated.

STEEL MAKING. Montreal Plant Produces Electric Furnace Steel in Large Quantities. *Can. Machy.*, vol. 42, no. 5, Mar. 5, 1931, pp. 27-30, 5 figs.; see also *Iron and Steel Canada*, vol. 14, no. 2, Feb. 1931, pp. 30-32, 3 figs. Canadian Tube and Steel Products, Ltd., Montreal, has become independent for their steel ingot and rod requirements through installation of electric steel-melting furnaces; installation consists of two Volta furnaces of Heroult type; electrode arrangements; furnace tilting; oxidation and reduction; low voltage use; ingot stripping.

Generators

HIGH-VOLTAGE. New Surge Generator. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, p. 245, 2 figs. Trend toward increased insulation for given operating voltage has necessitated higher and higher testing voltages in recent years; improved equipment to provide 1,000-kv. 60-cycle, and 3,000-kv. surge voltages has therefore been installed at Trafford High Voltage Laboratory; new equipment will greatly facilitate development work on insulation, as it is now necessary to determine performance on lightning voltages of all high-voltage apparatus.

High-Voltage Surge Testing, F. R. Benedict. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 216-218, 10 figs. In performing high-voltage surge tests on apparatus it is essential that shape of surge generator wave be under accurate control; steepness of wave front, magnitude of crest, and duration of tail can all be varied by use of proper circuit constants; elimination of oscillations at crest of wave is of considerable importance from standpoint of voltage measurement.

Grounding

CABLES. Der Doppelerdschlusstrom in Drehstromkabeln und seine Einwirkung auf benachbarte Fernmeldekabel (Double Ground Current in Three-Phase Cables and its Effect on Nearby Telephone Cables), W. Wild. *Wissenschaftliche Veroeffentlichungen aus dem Siemens-Konzern*, vol. 10, 1931, pp. 51-77, 25 figs. Origin is studied on basis of equivalent circuit diagrams; it is concluded that, with consideration of loads already present before occurrence of double ground, networks fed from one end are to be considered as networks fed from either end; protection is deduced from impedance diagrams; study of harmonics. Bibliography.

Heating

BUILDINGS. Building Heating. *Elec. Rev.*, vol. 108, no. 2786, Apr. 17, 1931, pp. 689-690, 3 figs. Advantages of load are such as to justify low rates; notes on electrode boiler and thermal storage; tabular and panel heating; electricity and heating load.

Hydroelectric

PIPE LINES. Design of Pipe lines for Hydroelectric Plants, J. S. Carpenter. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 418-419. To secure most economical design of pipe line for given condition, diameter and thickness are figured by modification of Enger's formula.

POWER PLANTS. The Economics of Power Plant Design, H. G. Acres. *Elec. News*, vol. 40, no. 7, Apr. 1, 1931, pp. 36-38 and 47, 8 figs. Fixed charges and operating expenses should be considered as definite factors in design of all plants; this is well illustrated in design and construction of recently completed development for municipality of Edmundston, New Brunswick.

Hydroelectric Units Operated as Condensers, H. A. Von Eiff. *Power*, vol. 73, no. 17, Apr. 28, 1931, pp. 666-669, 5 figs. Operating hydroelectric units as synchronous condensers under certain load conditions offers possibilities of large economies in plant operation; units in Holtwood plant of Pennsylvania Water and Power Company operated as condensers; method of solving problems encountered in operation and saving attained from condenser operation; curves of water saving by condenser operation on 25-60 cycle system; power for condenser operation.

Automatic Operator for 60,000-Hp. Station, A. C. Clogher and E. N. Peterson. *Elec. World*, vol. 97, no. 16, Apr. 18, 1931, pp. 716-722, 7 figs. Control of system frequency, division of load between units and change of one unit from generator to condenser operation are automatically and very successfully performed at Morony hydroelectric development of Montana Power Co.; station is located on Missouri River about 18 mi. below Great Falls, Mont.; two 22,500-kw. units are installed.

Rock Island—A Power Development on the Columbia River, T. B. Parker. *Elec. Light and Power*, vol. 9, no. 5, May 1931, pp. 22-27, 7 figs. Hydroelectric development is being built for Washington Electric Co., subsidiary of Puget Sound Power & Light Co., principal distributor of power in western Washington; it will be first large low-head development in Northwest; designed for ultimate capacity of 150,000 kw. under normal head of 48 ft.; initial installation will be 60,000 kw.

Industrial Progress

RUSSIA. Russia, H. L. Cooper. *Engrs. and Eng.*, vol. 48, no. 4, Apr. 1931, pp. 76-86. How communism has come about, as told by consulting engineer for 800,000-hp. hydroelectric and navigation project under construction on Dnieper River in Russia; statistics of Dniebrostroi hydroelectric projects; organization and how work is being done; statistics about Dnieprostroi hydroelectric development; notes on Five-Year Program.

Insulation

The Physics of Insulating Materials—V, A. M. Thomas. *World Power*, vol. 15, no. 88, Apr. 1931, pp. 307-310. Failure of dielectrics under stress; discharges in solids; mechanical deformation of dielectric due to electric force. Bibliography.

LINES, HIGH TENSION. Performance of Wood Insulation in Transmission Lines, F. E. Andrews. *Elec. World*, vol. 97, no. 17, Apr. 25, 1931, pp. 780-782, 5 figs. No interruptions due to lightning flashover as indicated by line trip-outs and no cases of 60 cycle power arcs following lightning flashover are recorded for 1930 on 90 mi. of all-wood constructed 33-kv. lines on Public Service Co. of Northern Illinois' system; this performance compares with respective figures of 42 and 30 for same items per 100 miles of line on 1025 mi. of previous construction.

MACHINERY. What is Good Insulation on Electrical Machines, J. L. Rylander. *Power*, vol. 73, no. 11, Mar. 17, 1931, pp. 438-441, 5 figs. Insulation failure is common evil of all electrical equipment; outline of methods for determining failure when cleaning and drying of electrical machine; effect of moisture and temperature; insulation values of different types of electrical machines as determined by tests.

MICA. The Permittivity and Power Factor of Micas, C. Dannatt and S. E. Goodall. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 490-496, 5 figs. Attention is drawn to electrode difficulty in testing mica, and tests are described which show order of contact effect which may be obtained with ordinary mercury electrodes; means are described by which electrode contact effect with mica may be entirely eliminated, and test results are given proving this point; test results on power factor and permittivity of ruby, green, and amber micas are given.

Light and Lighting

HIGHWAY. Illuminated Highways are Safer, D. M. Diggs. *Nat. Safety News*, vol. 23, no. 5, May 1931, pp. 19-20, 58 and 60, 5 figs. Examples showing that modern highway lighting lessens dangers that lurk in darkness and aids night travel.

INDUSTRIAL. Maintenance of the Illumination System of an Industrial Plant, R. C. Smith. *Mech. Eng.*, vol. 53, no. 5, May 1931, pp. 371-375, 6 figs. Details and results of efficiency and depreciation study of shop-lighting fixtures undertaken to obtain definite data upon which to base recommendations regarding lamp renewals and cleaning schedules. Before "Three-M" (Management, Materials, Maintenance) Congress, Cleveland, Ohio, previously indexed from advance paper.

MEASUREMENT. The Photoelectric Cell and Electric Clock as a Means of Recording the Daily Hours of Bright Sunshine, W. A. Thomson. *Can. Jl. Research*, vol. 4, no. 3, Mar. 1931, pp. 299-303, 2 figs. Method is presented whereby accurate record of daily hours of bright sunshine is made by electric clock, controlled, through relay, by intensity of light incident upon cathodes of suitably exposed photoelectric cell.

Lightning

MEASUREMENTS. Instruments for Lightning Measurements, C. M. Foust. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 235-246, 35 figs. Latest developments and applications of surge-voltage recorders; cathode-ray oscillographs; lightning-stroke recorders; surge indicators; lightning-severity meter.

Lightning Arrester

The Theory of Surge Absorbers, J. M. Thomson. *Elec. News* vol. 40, no. 9, May 1, 1931, pp. 41-42, 2 figs. Device that is essentially air core inductance connected in series with line, close to apparatus to be protected, and is operated by wave-front steepness of surge.

Magnetic Testing

IRON AND STEEL. Non-Destructive Tests by the Magnetic Dust Method, A. V. deForest. *Iron Age*, vol. 127, no. 20, May 14, 1931, pp. 1594-1595, 2 figs. Methods using magnetized iron filings for detecting cracks in ground surfaces, fatigue cracks in forgings and defects in seamless tubing; reference to work by W. E. Hoke and T. R. Watts. Before Am. Soc. Steel Treating and Am. Welding Soc.

Motor-Generators

Automatic Emergency Generating Sets, D. A. Bower. *Power Engr.*, vol. 26, no. 300, Mar. 1931, pp. 86-89 and 109, 5 figs. Sources of emergency supplies; development of emergency generating sets; principle of operation; general arrangement of emergency flywheel generating set; emergency set performing mechanical work; general layout of flywheel generating set arranged normally to perform mechanical work.

Motors

FRACTIONAL HORSEPOWER. The Woods High-Torque Fractional Horse-Power Motor, *Engineering*, vol. 131, no 3408, May 8, 1931, p. 604, 3 figs. This type of motor has disadvantage of requiring commutator, which introduces complication that may easily lead to breakdown; moreover, to short-circuit rotor windings when motor has run up to speed, it is necessary to employ either brush-lifting device or segmental brush; to overcome disadvantages M. W. Woods, London, have designed line of machines in outputs ranging from 1/8 to 1/4 hp. at speeds of from 2800 to 700 r. p. m.

STANDARDIZATION. Adaptable Electric Motors, E. G. Ross, *Elec. Rev.*, vol. 108, no. 2786, Apr. 17, 1931, pp. 664-665, 1 fig. Analysis of "special" requirements of mechanical firms shows that they can be so classified as to render perfectly feasible issuance of British Standard Specification covering exterior shapes of motors of from 1-hp. to 250-hp. rating, while simultaneously making clear that any radical production alterations are not involved.

Networks

DESIGN. Network Promises Marked Economies, D. K. Blake. *Elec. World*, vol. 97, no. 11, Mar. 14, 1931, pp. 492-495, 10 figs. Network principle promises to reduce light and power system cost and to improve service standards if it is applied to several voltage levels used in industry, simplifies system layout and engineering, makes possible manufacture of standard apparatus of single rating on production scale and reduces system investment per unit of capacity and improves service standards at minimum cost.

An A-C. System of Distribution, J. P. Heslop. *Elec. Rev.*, vol. 108, no. 2783, Mar. 27, 1931, p. 544, 2 figs. System described is claimed to possess flexibility and economy of a-c. with reliability of d-c. operation; oil circuit breakers ar installed in power station only, adjacent substations being supplied from different feeders.

Designing 115-230 Volt Distribution for Modern Residential Districts, G. L. Lillie. *Elec. News*, vol. 40, no. 9, May 1, 1931, pp. 37-40 and 50, 10 figs. Fundamentals of economical service outlined; transformers should be spaced 400-600 ft. apart; secondary conductors vary from no. 0 to no. 0000.

INTERCONNECTED. Transmission and Interconnection, P. M. Downing. *Elec. Light and Power*, vol. 9, no. 5, May 1931, pp. 20-21. California's experience in diversity, load factor, rural electrification and percentage of homes wired is direct criterion of country-wide results to be expected from extension of transmission lines and their interconnection.

Phase Advancers

The Theory and Performance of Phase Advancers, J. J. Rudra and M. Walker. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 445-469 and (discussion) 469-486, also author's closure 486-489, 52 figs. Advancers are divided into "expedor" advancers in which voltage is proportional to secondary current, and "susceptor" advancers in which it is proportional to secondary voltage; effect of these are considered when connected to ideal motor having circle diagram of infinite radius and sets out simple relations between angle of advancer and kva. required to do what is desired.

Photoelectric Cells

Progress in Photoelectric Cells, A. J. McMaster. *Radio Industries*, vol. 5, no. 12, Apr. 1931, pp. 597-598 and 612-618, 3 figs. Types of light sensitive cells; theory of photoelectric action; cell manufacture; application; operating requirements.

Potentiometers

An Improved Feussner Type Potentiometer, M. Eppley and W. R. Gray. *Rev. Sci. Instruments*, vol. 2, no. 4, Apr. 1931, pp. 242-249, 7 figs. There are two improvements in design that can be made, one to both earlier and later forms as currently imported into United States, other to later self-checking type only; they are elimination of six contact resistances affecting measuring circuit, and addition of another standard cell dial, making it possible to adjust standard cell circuit to five places instead of to only four.

Power Factor

Checking Reverse Relay Connections, C. F. Dalziel. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 180-181, 2 figs. Most expedient method of over-all check is to connect voltmeter and ammeter in circuit with wattmeter, and from readings taken as outlined, sufficient data are obtained in order to permit power factor and "system" present to be computed; wattmeter readings obtained using voltage from potential terminals of relay. (Concluded.)

Controlling Power Factor Automatically, A. Smith. *Power*, vol. 73, no. 16, Apr. 21, 1931, pp. 632-634, 5 figs. By proper selection of motors in large industrial plant it is possible, by automatically controlling field current of large synchronous motor, to maintain plant power factor at unity; favorable power rate is obtained because of high power factor and other operating conditions; charts of power factor, incoming plant kilowatts and voltage recorded by graphic instruments; operating results.

IMPROVEMENT. Synchronous Motors Will Solve the Power Factor Problem. *Ry. Elec. Engr.*, vol. 22, no. 4, Apr. 1931, pp. 100-101 and 114, 1 fig. Modern machines combined with simplified control equipment have resulted in many successful applications that were once considered impracticable.

MEASUREMENT. Simple Power-Factor Measurement, O. Wiemer. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 186-187, 2 figs. If only instrument available is a-c. ammeter of suitable range, it is still possible and often very convenient to make power factor test; this can be done by three-ammeter method; method does not necessarily require use of three separate ammeters as name would seem to imply; equally satisfactory results can usually be obtained with only one ammeter if few simple precautions are taken.

Power Supply

RURAL. Rural Electrification Progresses in Illinois, R. Boonstra. *Elec. World*, vol. 97, no. 15, Apr. 11, 1931, pp. 693-694. Progress in rural electrification made by Public Service Co. of Northern Ill. during 1930 indicates that much can be done even in a bad business year in extending lines to farm customers and in promoting use of energy by those customers.

Radio

AMPLIFIERS. A New Method of Testing for Distortion in Audio-Frequency Amplifiers, H. J. Reich. *Instn. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 401-415, 12 figs. Periodic voltage wave consisting of series of straight lines is distorted into series of curves when it passes through amplifier which gives nonuniform amplification; as such distortion can very readily be detected visually with oscillograph, it affords means of testing for uniformity of amplification; mathematical analysis shows that "saw-tooth" voltage wave is distorted into series of exponential curves in passing through resistance-capacity-coupled amplifier.

ANTENNAS. Radio Antennas, E. F. Martin. *Radio Eng.*, vol. 11, no. 4, Apr. 1931, pp. 39-41, 7 figs. Theory of antenna arrangements; their properties of transmission and reception.

BEACONS. A Radio Beacon and Receiving System for Blind Landing of Aircraft, D. Diamond and F. W. Dunmore. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 4, Apr. 1931, pp. 585-626, 29 figs., partly on supp. plate. Receiving system for use at airports to permit blind landing of aircraft under conditions of no visibility; system comprises three elements to indicate to pilot position of aircraft as it approaches and reaches instant of landing; same medium-frequency receiving set required for obtaining radiotelephone and radio range beacon service on airways is utilized for receiving runway localizing and marker beacon signals.

COILS—RESISTANCE. The High-Frequency Resistance of Coils, A. L. Green. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 183-191, 6 figs. It is shown that there are methods of measuring high-frequency resistance of coils which do not require use of thermo-junction and calibrated resistances; these methods depend on condition for oscillation in triode assembly, and simplest of them uses dynatron oscillator.

OSCILLATORS. Calculation of Electric and Magnetic Field Strength of any Oscillating Straight Conductors, R. Bechmann. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 461-466, 1 fig. Theoretical mathematical analysis from results obtained by use of method which depends on formation of Hertzian vectors.

RECORDERS. An Automatic Recorder of Signals from A Rotating Beacon Transmitter, R. L. Smith-Rose and H. A. Thomas. *Sci. Instruments—Jl.*, vol. 8, no. 3, Mar. 1931, pp. 81-88, 5 figs. Automatic apparatus which has been developed for recording of wireless bearings from rotating beacon transmitter of type now in operation at Orfordness, Suffolk; output telephone signal current from standard type of valve receiver is supplied to tuned audio-frequency amplifier followed by rectifier; output current from this rectifier operates relay and pen which traces line record upon sheet of paper placed on rotating drum.

TRANSFORMERS. The Resistance Capacity Coupled Transformer, F. Aughtie. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 177-182, 7 figs. Use of choke in anode circuit and transformer primary being fed through suitable coupling condenser has long been known and used; authors favor circuit of where choke is replaced by resistance, by this substitution, besides removal of potential source of distortion, in shape of additional iron core, smaller self capacity of resistance as compared with choke, renders possible improvement in performance of stage at high frequencies.

ULTRA-SHORT WAVE. Ultra Short-Wave Radio-Telephony. *Elec. Rev.*, vol. 108, no. 2785, Apr. 10, 1931, pp. 622-623, 4 figs. Dover-Calais demonstration of radio-telephony on 18-cm. wave-length which marks striking advance in technique of electro-optical directive operation.

A New Wireless System. *Engineer*, vol. 151, no. 3926, Apr. 10, 1931, p. 413, 5 figs. Demonstration was given on Mar. 31 by International Telephone and Telegraph laboratories of "Le Matériel Téléphonique," of Paris; by means of new wireless telephone and telegraph equipment, largely developed by French engineers, in Paris laboratories, two-way telephone communication was established between Dover and Calais, on wavelength as low as 18 cm.

Railroad

ELECTRIFICATION. Suggestions as to the Future of Railroad Electrification, F. H. Shepard. *New York Railroad Club—Off. Proc.*, vol. 41, no. 5, Mar. 1931, pp. 9561-9653. Future outlook of electrification in America; reasons for extension.

Heavy Electric Traction Progress in America, C. Kerr, Jr. *Tramway and Ry. World*, vol. 69, no. 19, Apr. 16, 1931, pp. 187-190, 8 figs. Brief review of two outstanding installations; design, construction and operating developments in locomotives motor development; control improvements; Deion trolley breakers, frequency changer sets.

POWER FACTOR IMPROVEMENT. Importance of Power Factor Improvement, W. K. Fuzzelle. *Ry. Elec. Engr.*, vol. 22, no. 3, Mar. 1931, pp. 75-76 and 83. Transmission and distribution systems loaded with wattless current cannot function economically; remedy lies in wider application of synchronous motor.

Rating

ELECTRIC MACHINERY. New Ratings for Electrical Machinery. *Elec. World*, vol. 97, no. 15, Apr. 11, 1931, p. 679. Recommendations of International Electrotechnical Commission proposed for international use at recent seventh plenary meeting, held in Stockholm *i. e.*, internationally specified limits of temperature rise for rotating machines and transformers; temperature rises reduced for use in tropical climates; tolerances allowable in electrical machine ratings.

Reactive Power

ELECTRIC METERING. Reactive Kva. Metering—VII, E. C. Goodale. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 181-183, 3 figs. Effect of unbalanced load upon accuracy of registration of three-phase three-wire reactive meters.

Rectifiers

CONTROL. On the Contact Conduction and Rectification, G. Hara. *Ryojun College of Eng.—Memoirs*, vol. 3, no. 4-A, 1931, pp. 223-224, 19 figs. Author intends to deduce approximate formula for contact conduction applying cold emission theory to contact, and also to make clear mechanism of contact and rectification. Bibliography. (In English.)

Resistance

GROUND. The Measurement of Earth Resistances, G. F. Tagg *Elec. Times*, vol. 79, no. 2061, Apr. 23, 1931, pp. 741-743, 6 figs. Regulations as to earthing; systematic tests; elementary methods of measurements; three point method; bridge methods; fall of potential method; Siemens-Halske earth tester; meggar earth tester; specific resistance of earth.

MOISTURE FILMS. Electrical Resistance of Moisture Films on Glazed Surfaces, G. G. Smail, R. J. Brooksbank, and W. M. Thornton. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 411, Mar. 1931, pp. 427-436, 15 figs. Research is described in two parts, first dealing with relations between surface resistivity, humidity and temperature, and second with influence of gas pressure, both having for their object discovery of laws of film formation under controlled conditions.

Spark Gaps

ELECTRODES. The Development of an Electron Emitting Alloy, O. S. Duffendack, R. A. Wolfe and D. W. Randolph. *Electrochem. Soc.—Advance Paper*, no. 59-17, Apr. 27, 1931, pp. 157-173, 11 figs. After many experiments, nickel alloy containing barium has been developed which is homogeneous in composition and readily reproducible; spark gaps having electrodes made of this alloy have very constant sparking voltages; alloy has marked electron emitting properties that make it valuable for use in various electrical devices; its uses in several ways are being developed.

Stability

ALTERNATORS. Power System Stability, F. A. Hamilton, Jr. *Eng. Jl.*, vol. 14, no. 4, Apr. 1931, pp. 227-242, 31 figs. Methods of predicting power limits under steady or transient conditions have been outlined in various publications and are available to system designers; paper presents in more elementary fashion certain concepts upon which these methods are based; factors which affect power limits are discussed and their interrelation illustrated; methods of increasing power limits are discussed.

Starting

ELECTRIC MACHINERY. The Starting Motors, J. Sachs. *A EG Progress*, vol. 7, no. 4, Apr. 1931, pp. 85-91, 11 figs. Starting processes obtaining with asynchronous and synchronous machines when employing starting motors; it is indicated by few examples that with large machine units, but particularly phase advancers, employment of starting motors exercises very favorable effects upon starting conditions, such as smaller apparent power consumption, smaller initial current surges and higher power factor.

Substations

RECTIFIER. La sous-station automatique d'éclairage de Cannes (Automatic Substation). *Genie Civil*, vol. 98, no. 5, Jan. 31, 1931, pp. 117-118, 4 figs.; see also brief translated abstract in *Power Engr.*, vol. 26, no. 301, Apr. 1931, p. 156. Equipment of Bergerie, Cannes substation converts 10,000-volt three-phase, 25-cycle supply into continuous current at 250 volts for lighting and general service; in order to avoid noise or other nuisance, mercury-vapor rectifier was adopted as converting equipment.

Switchboards

SPECIFICATIONS. Nema Panelboard and Distribution Board Standards. *Nat. Elec. Mfrs. Assn.—Pub.*, no. 31-4, Jan. 1931, 31 pp., 11 figs. Standards on design and construction of panelboards; switchboards; cabinets and equipment boxes; commercial standard practise.

SUPERVISORY CONTROL. Supervisory Control Equipment. *Elec. Rev.*, vol. 108, no. 2784, Apr. 3, 1931, p. 611, 2 figs. Supervisory equipment for remote control of three substations, two of rotary type for traction purposes and one of transformer type, of Auckland Electric Power Board in New Zealand, has recently been completed by Automatic Telephone Manufacturing Co., Ltd., in collaboration with Metropolitan-Vickers Electrical Co., Ltd.; descriptive details of apparatus is given.

Switchgear

LOSSES. Eddy Current Losses in Heavy Current Switchgear—II, J. E. Shaw. *World Power*, vol. 15, no. 88, Apr. 1961, pp. 295-299, 8 figs. Iron loss in mold steel, switch tops; experimental results of measurements discussed in detail; experimental investigation of iron loss in plate, due to single conductor carrying current definite distance from it. (Concluded.)

Synchronizers

CLOCKS, ELECTRIC. Ein funkenfreier Synchronisier-Apparat fuer Nach- und Voreilen (Spark Free Synchronizer for Lagging and Advanced Currents), H. Bock. *Zeit. fuer Instrumentenkunde*, vol. 51, no. 4, Apr. 1931, pp. 197-204, 5 figs. Synchronizing equipment, for electric pendulum clocks, is detailed.

Television

QUALITY. Quality of Television Images, D. K. Gannett. *Bell Laboratories Rec.*, vol. 9, no. 8, Apr. 1931, pp. 358-362, 5 figs. Since each cycle represents two picture elements, number of picture elements which could be received is 10,000 in second, or 625 in 1/16 of second; no matter how good television apparatus, therefore, no better quality picture could be obtained than containing 625 elements, or about 22 by 28 elements.

Transformers

Recent Progress in Large Transformers, R. M. Charley. *Instn. Elec. Engrs.—Preprint*, for mtg., Apr. 16, 1931, 15 pp., 16 figs. General description of progress made in recent years and examples illustrating present stage of art.

Ultra Violet

WINDOW GLASS. Glasses for Use with Invisible (Ultra-Violet and Infra-Red) Rays, S. English. *Jl. of Good Lighting*, vol. 24, Feb. 1931, pp. 27-31 and (discussion) 32-35, 13 figs.; see also *Nature (Lond.)*, vol. 127, no. 3200, Feb. 28, 1931, pp. 310-312, 2 figs. Nature of invisible rays; spectrum; characteristics of certain radiations; ultra-violet transparencies of two glasses of similar composition; relative transparency of various glasses; ultra-violet transmission of various window glasses; effect of artificial aging on two types of ultra-violet glass; spectra of various ultra violet light sources; Wood's glass and fluorescence; light transmission and heat absorption of various glasses.

Vacuum Tubes

GLOW. A New Television Lamp, G. Gruskin. *Radio Industries*, vol. 5, no. 12, Apr. 1931, pp. 593 and 611-612, 1 fig. Development of radically improved type of point-source light by W. G. Taylor of Taylor Vacuum Products Co., does away with many limitations formerly ascribed to mechanical scanning; author has not yet been granted authority to release details of tube's construction or operating principles.

INDUSTRIAL APPLICATIONS. Vacuum Tubes In Industry, P. G. Weiller. *Radio Eng.*, vol. 11, no. 4, Apr. 1931, pp. 31-34, 4 figs. Important progress is being made in design and manufacture of mercury vapor rectifier tubes and tubes useful for automatic control of operating electric circuits; many opportunities await cooperative studies between tube engineers and engineers engaged in mechanical industries.

Voltage Regulators

The Application of the Induction Voltage Regulator, W. E. M. Ayres. *Instn. Elec. Engrs.—Preprint*, for mtg., Apr. 16, 1931, 11 pp., 21 figs. General application of induction regulators to feeder systems and distribution networks; problem of fully automatic control is dealt with and various methods of parallel working are discussed; point of application of regulator in system is considered from its practical and economic aspects.

Voltmeters

HARMONICS. Ein Oberwellen-Voltmeter (Harmonic Wave Voltmeter), R. Oetker. *Zeit. fuer Technische Physik*, vol. 12, no. 4, 1931, pp. 205-210, 10 figs. Description of simple and exact indicating instrument for effective value of harmonics of distorted voltage curve.

IONIC. The Ionic Wind Voltmeter and Thermo-Electrostatic Relay, W. M. Thornton and W. G. Thompson. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 533-544, 18 figs. Electric wind observed in neighborhood of highly charged point in air is caused by repulsion of ions which collide with uncharged molecules of air, thus giving to them velocity and, in effect; causing wind from point; instrument based on this action, termed "ionic wind voltmeter," was designed to indicate voltage of any system above few thousand volts by making earthed electrode part of hot-wire bridge.

Wave Filters

Extensions to the Theory and Design of Electric Wave-Filters, O. J. Zobel. *Bell System Tech. Jl.*, vol. 10, no. 2, Apr. 1931, pp. 285-341, 18 figs. Derivation and composition of wave-filter structures; designs of networks which simulate impedances of wave-filters, and of loaded lines; four Appendices contain new reactance and wave-filter frequency theorems, particular fixed transducer designs and certain equivalents.

Welding

ARC. Arc Welding in 1931, J. F. Lincoln. *West. Machy. World*, vol. 22, no. 2, Feb. 1931, pp. 65-66, 3 figs. Every year since war use of arc welding has gained greater momentum in practically every industry; regardless of economic outlook for 1931, it is safe to say that this process will be applied more widely and more frequently than in any preceding year; development of electrodes during past year for welding of various steel alloys will bring about much wider application of arc welding and in turn permit wider use of these alloy metals, particularly that of stainless steel and other corrosion-resisting metals.

Arc Welding Everdue, T. E. Jerabek. *Boiler Maker*, vol. 31, no. 3, Mar. 1931, pp. 68-69, 5 figs. Property of copper-silicon-manganese alloy, known as everdur; advantageous welding characteristics: procedure of metallic arc-welding process.

ARC-TESTING. Inspection Safeguards Quality, R. Kraus. *Welding Engr.*, vol. 16, no. 4, Apr. 1931, pp. 27-31, 14 figs. Inspection and testing methods of Westinghouse Co., with incorrect and correct sketches of welding procedure and layout of weld; testing of welders and dimensions of test specimens. Before Am. Soc. Testing Matls.

BOILER MANUFACTURE. New Technique in Welding is Result of Years of Scientific Research, K. B. Lydiard. *Pit and Quarry*, vol. 22, no. 2, Apr. 22, 1931, pp. 62-64, 11 figs. Results of investigations and laboratory experiments by research engineers of Babcock and Wilson; based on which technique was evolved which produces welds equal to or better than welded plate itself in tensile strength, shock resistance, ductility, and in ability to withstand repeated stresses; results obtained when this technique is used to weld carbon steel of firebox quality.

GAS PIPE LINES. Development and Results of Arc Welding of Gas Pipe Lines, H. C. Price. *Oil and Gas Jl.*, vol. 29, no. 48, Apr. 16, 1931, pp. 148 and 150. Review of development of electric welding of pipe lines, since 1928, with particular reference to long distance natural gas lines; operating practise; results; tests; advantages. Before Am. Gas Assn.

MACHINERY MANUFACTURE. Welded Construction Applied to Special Machinery, D. V. Waters. *Product Eng.*, vol. 2, no. 4, Apr. 1931, pp. 167-170, 6 figs. As result of development of acetylene and arc welding technique in recent years, welded steel construction in places where such construction was formerly deemed impracticable, is now used to good advantage; savings of both money and time in construction have resulted from use of welded steel; adaption of welding to special machine construction.

SHIPBUILDING. Electric Welding in the Construction of Sea-going Vessels, G. Wahl. *Shipbldg. and Mar. Engine Bldr.*, vol. 38, no. 251, Apr. 1931, pp. 321-326, 12 figs. Experimental ship constructed by Deutsche Werke in order to find new methods of electric welding applicable to shipbuilding and for training of welders; results of tests and conclusion. Before Instn. Engrs. and Shipbldrs. in Scotland.

VENTILATION DUCTS. Welded Fabrication of Ductwork, W. Spraragen. *Heat. and Vent.*, vol. 28, no. 3, Mar. 1931, pp 54-57, 9 figs. Preparation of material in repetitive production work; types of joints; expansion and contraction; stack welding.

Welding Machines

SPOT. The Dyer Bench Spot Welder. *Engineering*, vol. 131, no. 3401, Mar. 20, 1931, p. 408, 1 fig. Bench-type welder manufactured by Dyer Welding Machine Corp., Independence, Mo.; arrangement it is claimed, enables various parts to be joined together at place where they are assembled, thus saving time; welder is capable of making 1,000 welds per hr. on no. 16 gage sheet, variation in heat necessary for different metals being obtained through medium of three-position switch, which is fixed to housing containing transformer.

Industrial Notes

The Holophane Company, Inc., 342 Madison Avenue, New York, announces the appointment of A. D. Cameron as manager. Mr. Cameron was formerly active in the lighting field as manager of the lighting and supply division, central station department, General Electric Company, Schenectady, N. Y. Later he was vice-president of the Hall Electric Heating Company, of Philadelphia.

Ohio Brass Insulators Conform to New NEMA Standards.—To meet the new standards for switch and bus insulators decided upon at the May meeting of the National Electrical Manufacturers Association, the Ohio Brass Company, Mansfield, Ohio, announces a new line ranging in voltage ratings from 7.5 kv. to 69 kv. These new insulators, which simplify the construction, maintenance and repair problems of the user and make it much easier to coordinate line and station insulation, are now available for immediate shipment.

Miniature Relays.—A new line of miniature relays to be known as "Mid-Gett" is being made in eight contact arrangements by Struthers Dunn, Inc., 129 N. Juniper Street, Philadelphia. They are on standard bases and measure 1⅞ in. by 2¾ in., and follow in detail the design of regular type Dunco relays, having the three-legged stool principle of construction, form-wound, moisture-proof coils, renewable contacts, accessible terminals, with moulded bases. They operate on from 6 to 120 volts alternating current, or 24 volts direct current, depending upon the coil used.

New Vulcanized Fibre Insulation.—A new insulating material known as Dilecto K-4 is being produced by the Continental-Diamond Fibre Company, Newark, Del., manufacturers of Bakelite materials and vulcanized fibre. In addition to unusually high electrical insulating properties, Dilecto K-4 has high thermal insulating efficiency, is odorless and does not attract odors. It is finding a wide use as breaker strips on electric refrigerator cabinets. The material, which is highly resistant to alkali solutions and to water and moisture, will be made in sheets, rods and tubes, and can be machined readily.

Telegraph Code for the Electrical Industry.—A standard telegraph code for the electrical industry, sponsored by NEMA and other electrical associations, has been compiled under expert supervision for the use of the entire electrical field, not only for economy in communication, but to provide means for more frequent, accurate and comprehensive exchange of information of immediate necessity. According to the announcement it is the first instance of an entire industry uniting on a general code, and its cheap distribution is dependent upon the response to the pre-publication offer as detailed in the prospectus which is available upon application to the National Electrical Manufacturers Association, 420 Lexington Avenue, New York.

Trade Literature

Motors.—Bulletin 209, 32 pp. Describes type "D" heavy duty direct-current motors. Reliance Electric & Engineering Company, 1042 Ivanhoe Road, Cleveland.

Bridge-Stop Control.—Bulletin, 4 pp. Describes the new EC & M dynamic braking, bridge-stop control. This braking equipment is used on electrically operated overhead traveling cranes. The Electric Controller & Mfg. Company, 2700 East 79th Street, Cleveland.

Magnetic Clutches.—Bulletin, 24 pp., "Keeping Pace With Machine Design." Describes the construction, application and operation of C-H magnetic clutches, including a full description of the newly developed C-H duplex clutch. Cutler-Hammer, Inc., 12th & St. Paul Avenue, Milwaukee.

Circuit Breakers.—Bulletin 484, 4 pp. Describes type DR line oil circuit breakers, manual and electrical remote control, up to 2,000 amperes, 15,000 volts; 3,000 amperes, 7,500 volts; 60 cycle ratings, automatic or non-automatic. These breakers are designed for indoor service where space is an important factor. Condit Electrical Manufacturing Corporation, Boston.

Mercury Arc Rectifiers.—Bulletin 1907, 16 pp. Describes steel tank mercury arc rectifiers for converting alternating to direct current over wide ranges of both voltage and current. The most general use of this equipment is in supplying power for electric traction systems, although it has certain industrial applications. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Switchboards.—Bulletin 293, 18 pp. Describes Bull Dog "SaftoSwitch-Boards" type DF-30. These are of standardized sectional construction, totally steel enclosed, consisting of one or as many panels as desired, allowing changes or extensions, as requirements may demand. The scheme of standardization not only includes switches, but has been developed to cover air and oil circuit breakers, meters, etc. Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit.

Hardness Testing Machine.—Bulletin, 24 pp. Describes the Firth Hardometer. This device extends the reliable Brinell method of hardness testing for use with thin materials, case hardened or nitrided surfaces, small parts, or any condition where a small indentation is necessary or desirable. The Firth hardometer differs from other instruments intended for the same purpose in that the diameter or diagonal of the impression is measured instead of the depth. Tinius Olsen Testing Machine Company, 500 No. 12th Street, Philadelphia.

Power Filter Unit.—Bulletin, 4 pp. Describes a new power filter unit which converts alternating current into pure, non-pulsating, humless direct current for use on telephones, sound-on-film, public address systems, inter-communication systems, clock and signal systems, magnetic chuck operation, elevator control and many other applications. The use of batteries in connection with the power filter unit is unnecessary, except where a standby source of direct current is required. Square D Company, 6060 Rivard Street, Detroit.

Potentiometer Pyrometers.—Catalog 1101, 48 pp. Describes a new line of potentiometer pyrometers having a broad application to industrial needs involving the measurement and control of temperatures, especially in the higher ranges. The introduction outlines the nature and field of the potentiometer principle as applied to pyrometers. The various types of these instruments include indicating, recording, controlling, multiple recording and multiple controlling. The Brown Instrument Company, Windrim & Wayne Streets, Philadelphia.

Lightning Arresters.—Bulletin 20365-A, 4 pp. Describes autovalve lightning arresters for the protection of railroad signal apparatus. Bulletin 20149-G, 4 pp., describes type SV autovalve lightning arresters for station use either indoors or outdoors, 1,000 to 220,000 volts. Bulletin 20013-K, 8 pp., describes type LV autovalve lightning arresters for the protection of distribution transformers. Bulletin 1737-F, 24 pp., is a comprehensive, illustrated publication describing autovalve arresters in general and the correct method of installation. Detailed engineering discussions, supplemented by drawings and diagrams, clarify many arrester problems. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Annual Technical Committee Reports To the Board of Directors

In accordance with Section 82 of the A. I. E. E. By-laws, the Technical Committees of the Institute have prepared the following reports for presentation at the Summer Convention.

In addition to a brief outline of its own activities, each committee gives a resume of the progress of the art within its field, so that collectively, these reports constitute an authoritative history of the developments in electrical engineering during the past year.

Table of Contents

Automatic Stations 542

Communication 550

Education . . . . no report

Electric Welding 557

Electrical Machinery 561

Electrochemistry and Electrometallurgy . . . 570

Electrophysics 575

General Power Applications 580

Instruments and Measurements 587

Applications to Iron and Steel Production . . 590

Production and Application of Light 594

Applications to Mining Work 598

Applications to Marine Work 599

Power Generation 602

Power Transmission and Distribution 617

Transportation 620

Protective Devices 624

Research 627

Automatic Stations

ANNUAL REPORT OF THE COMMITTEE ON AUTOMATIC STATIONS*

CONSIDERABLE data on many phases of the automatic station art have been collected by subcommittees and are made part of this report, which is treated under headings as follows:

- Technical Papers
- Standards
- New Subjects
- Unfinished Business
- Fire Protection
- Wire Designations
- Research
- Operating Data
- Telemetering
- Bibliography

TECHNICAL PAPERS

The following papers are being presented under the auspices of the Committee at the Summer Convention, Asheville, N. C., 1931.

1. *A-C. Supervisory Control System.* By Othmar K. Marti.
2. *Supervisory Control for A-C. Electrified Railroads.* By C. P. West and H. C. Griffith.
3. *Automatic Combustion Control.* By C. H. Sanderson and E. B. Ricketts.
4. *Operating Experience with Automatic Stations.* By Garland Stamper and F. F. Ambuhl.
5. *Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control.* By R. M. Stanley.

STANDARDS

Standards No. 26, Automatic Stations, has again been reviewed by the Committee. Recommendations for revisions in the list of device function numbers and in the table of minimum protection for power apparatus have been forwarded to the Standards Committee.

NEW SUBJECTS

Automatic combustion control and automatic alternating current networks have been studied this year by the Committee. A paper on Automatic Combustion Control, covering this subject extensively for the first time, is being presented at the annual convention.

UNFINISHED BUSINESS

Of the items listed last year, preliminary reports on Fire Protection, Load Dispatching and Wire Designations have been completed and are contained herein.

The following topics have been under consideration but no final reports have been rendered:

1. Economical Construction.
2. Noise Mitigation.
3. Automatic Alternating Current Networks.
4. General Telemetering.

SUBCOMMITTEE REPORTS

To the Subcommittees contributing the following reports generous acknowledgment is given. It is desired to make known that the efforts so prominently reflected in these reports are appreciated in full measure.

FIRE PROTECTION

Contributed by I. E. Moultrop and D. W. Taylor.

The methods of accomplishing suitable fire protection from the points of view of safety to personnel, safety to apparatus, and continuity of service have long been the subject of discussion and investigation by the electrical engineering profession. The size and importance of electrical installations make adequate fire protection a matter of utmost importance. The increasing use of automatically operated stations brings into prominence the special problems confronted by the designers of these usually unattended installations, which may in some instances be so far removed from the nearest aid in case of fire as to make automatic fire protection a corollary of automatic operation. It is the purpose of this report to point out some of these special problems.

When the subject of fire protection is considered, it is well to make a study of the causes of fires to obtain a perspective of the various elements entering into the problem. Consideration can then be given to design, and apparatus and material specifications, which will eliminate as much as possible the trouble at the source. Studies may be made to determine if oil circuit breakers have the necessary interrupting capacity; if all load carrying apparatus has the proper thermal capacity; if relay protection can be provided to clear short circuits before damage may occur, etc. Many apparatus characteristics, such as oil circuit breaker interrupting capacities, have been proven by tests so that greater reliability may be placed in their performance than was the case a few years ago.

Means to limit the fire to the vicinity of its source and prevent involving other apparatus in an attended or unattended substation, may take any one or more of three forms, *viz.:* automatic means of fire detection and alarm; structural means of fire isolation; and means of fire fighting, either manual or automatic.

---

*COMMITTEE ON AUTOMATIC STATIONS:

F. Zogbaum, Chairman,
Chester Lichtenberg, Secretary,
F. F. Ambuhl,
L. D. Bale,
C. W. Colvin,
A. M. Garrett,
Joseph Hellenthal,
O. A. Mayo,
I. E. Moultrop,
M. E. Reagan,
O. J. Rotty,
Garland Stamper,
D. W. Taylor,
L. J. Turley.

Automatic means of fire detection, as at present commercially developed, take the form of thermocouples and fusible links to convert the heat energy released by combustion into electrical energy, or of the more complicated apparatus working as a detector of the resultant smoke. Although these automatic means of fire detection have occasionally been installed in attended stations merely to alarm the operators, the recent mechanical improvement of the devices commercially obtainable for this service has resulted in considerable application of such devices in unattended stations to give alarm at some central attended installation and/or to operate fire-fighting equipment adjacent to the source of trouble. Unattended stations whose operations are reported to a central office through some means of supervisory control are particularly adapted for the installation of an alarm system between the station and the central office.

The second form of fire protection, structural means of fire isolation, is applied for the same reason and with equal effect in both attended and unattended stations. The large quantity of oil used in modern electrical apparatus makes fire isolation an important problem both indoors and outdoors. Generally, if possible, it is desirable to install large oil-filled apparatus outdoors and eliminate as much indoor oil-filled apparatus as is possible.

Indoors, apparatus of different types and different degrees of importance may be placed in different rooms, with fire doors between, either normally closed or closed by gravity upon the release of a fusible link. Some companies go so far as to install oil-immersed transformers in one room, large oil circuit breakers in a long narrow room with windows only at the ends, and oil-immersed voltage regulators in still another room; only the smaller breakers being installed in the same room with the switchboard and major bus structure. In connection with the location of windows, many stations are so arranged that any outdoor apparatus liable to catch fire, if installed adjacent to the building wall, are located at considerable distance from the nearest opening into the building. Another precaution taken as a means of indoor fire isolation comprises the use of cell doors and other trim made of treated wood or other fireproofed material. Current transformers, on which the relay protection is dependent, have been sometimes placed in separate compartments so they will not be involved in an arc from other equipment before they have actuated the tripping relays. Proper grounding of apparatus often lessens the chance of stray currents damaging other equipment during a short circuit. Elimination, as much as possible, of unprotected apparatus connected to the main bus is often desirable. Protection of apparatus, such as bus potential transformers, by means of resistance and fuses and careful isolation of bus arresters, should be considered.

Outdoors, transformers may be installed with fire walls between banks of two or three units or, if larger and more important transformers, between individual units. One company has recently adopted the policy, on large outdoor transformers, of eliminating the column-type oil gage from the conservator and of installing fuse-releasing gravity-closing valves on all connections between conservator and main tank. It is intended by this policy to prevent the spreading of possible transformer fires by the release of the large quantity of oil contained in the conservator, as sometimes happens through the cracking of the gage glass on the occurrence of fire in the immediately adjacent transformer and through the feeding out of burning oil from a rupture in the cover of a faulty transformer.

Both indoors and outdoors, fire isolation may be augmented by the installation of pits and drainage systems properly disposed with respect to oil-immersed transformers and regulators and oil circuit breakers.

The third form of fire protection, means of fighting the actual fire, divides naturally between the use of liquids and the use of gases. The most obvious liquid for this purpose is water, which is often piped to the end-bells of large rotating machinery and may be used elsewhere in connection with one of the commercial sprinkler systems; there is, however, considerable question as to the efficacy of water as a means of fighting oil fires. Other liquids take the form of special preparations, often generated on the premises at the time of fire, either by the mixture of two liquids or of water and a powder. Gaseous means are limited commercially to the use of carbon dioxide, which is heavier than oxygen and serves to smother the fire when applied in sufficient concentration; it is therefore particularly suitable in confined spaces where liquid might damage the apparatus and/or where the gases emanating from some of the commercial liquid preparations would be obnoxious. The efficacy of all these fire-fighting fluids may be considerably increased by the installation of permanent piping, designed to permit the direction of the fluid at the most advantageous point in case of fire. Whether or not the valves of this piping should be automatically operated depends not only upon the importance of the installation and the liability of a large fire, but also upon the proximity to a central attended installation and the attendant costs of automatic equipment for fire alarm as compared with the costs of automatic equipment for fire fighting in the unattended station.

It is believed that the art of fire protection is developing so rapidly, particularly in connection with unattended automatic stations, that no standards should be promulgated at this time by the American Institute of Electrical Engineers or others. It is thought that only by giving comparatively free rein can it be assured that progress will continue to be made in accordance with the best economic dictates.

The attached Appendix A is a preliminary attempt to classify for further investigation or study, I. the causes of fires, II. the spreading of fires, III. preventive measures, and IV. the extinguishing of fires.

Appendix A

I. Causes of Fires. II. Spreading of Fires. III. Preventive Measures. IV. Extinguishing of Fires.

I—Causes of Fires

A. Faulty Design
  1. Insufficient spacing.
  2. No allowance for temperature changes.
  3. Reduced clearances from distortion due to short circuits.
  4. Conductors or equipment improperly or insecurely supported.
  5. Weakness of mechanical structure or supports.
  6. Insufficient provision against heaving by frost, entrance of rain, or accumulation of sleet.
  7. Cannon construction (by cannon construction is meant the arrangement of barriers or compartments in such a manner as to direct an arc outward into other equipment or into operating aisles).

B. Faulty Equipment
  1. Improper design.
  2. Poor material.
  3. Defective materials or parts.
  4. Insufficient insulation, spacing of parts, strength or thermal capacity.
  5. Improper assembly.
  6. Improper and insufficient testing.
  7. Unnoticed failures as a result of testing.

C. Improper Application of Equipment
  1. Wrong material—moisture absorbing, subject to chemical change.
  2. Wrong apparatus—type, size, rating.

D. Aging of Apparatus and Material
  1. Deterioration of insulating material on conductors, supports, windings.
  2. Corrosion of metals from action of air, moisture, electrolysis.
  3. Effect of moisture, gases and corona in hastening deterioration.

E. Static Stresses
  1. Causing destruction of insulation.
  2. Collecting conducting material.

F. Magnetic Stresses
  1. Mechanical movement.
  2. Collecting conducting material.

G. Surges or Lightning
  1. Atmospheric conditions.
  2. Switching operations.
  3. Improper grounding.

H. Arcs (other than flashovers)
  1. Switching operations.
  2. Contactors.
  3. Commutators.

I. Exceeded Ratings
  1. Exceeded current rating, overload.
  2. Overvoltage.
  3. Exceeded temperature rating.
  4. Exceeded time.

J. Errors in Operation

K. Failure of Apparatus Containing Oil
  (This includes oil circuit breakers, oil switches, transformers, potheads, etc.)
  1. Insufficient amount of oil.
  2. Surplus amount of oil.
  3. Slopping of oil (mufflers, discharges).
  4. Dripping of oil on other apparatus.
  5. Lowering of oil level due to leaks, syphoning or intense cold.
  6. Freezing of oil.
  7. Carbonization of oil.
  8. Presence of moisture.
  9. Explosions due to arcs following short circuits.
  10. Poor contact.
  11. Puncture of bushing.
  12. Internal corona discharges.
  13. Internal earth fault.
  14. Internal short circuit.
  15. Phase interruptions due to mechanical failures.
  16. Short-circuited laminations.
  (Note: See other sections for failure of apparatus in general).

Exposure to External Attack
  1. Animals—birds, rats, nests, etc.
  2. Foreign material thrown on equipment—stones, kite strings, airplanes.

M. Dirty Apparatus
  1. Dirt from coal piles, or adjacent industries.
  2. Boring action of metallic slivers.
  3. Causing reduced radiation.
  4. Causing flashovers.

N. Spontaneous Combustion
  1. Oily waste or rags
  2. Coal.

O. Friction
  1. Lack of lubrication.
  2. Improper alinement.
  3. Dirt.

P. Condensation
  1. Unheated conditions.
  2. Temperature changes in conduits.
  3. Unventilated conditions.
  4. Wrong materials.

Q. Heating Equipment and Piping
  1. Failure of electrical heaters.
  2. Defective flues.
  3. Explosions of oil burners.
  4. Escaping steam or water from pipes.
  5. Broken fuel lines.

R. Carelessness
  1. Improper tagging or operation (disconnects, etc.).
  2. Cigarettes, matches.

S. Atmoshperic Conditions
  1. Flashovers due to fogs, especially salt water fogs.
  2. Sleet or wind.

T. Exterior Fires
  1. Adjacent buildings.
  2. Grass and forest fires.

II—Spreading of Fires

A. Inflammable Material in Apparatus.
  1. Insulating material in conductors, such as rubber and varnished cambric.
  2. Insulating supports or braces, such as wood.
  3. Oil or inflammable compounds.

B. Inflammable Material in Construction
  1. Wooden buildings, compartments, or structures.
  2. Forms used during construction.

C. Insufficient Segregation
  1. Insufficient barriers, compartments, cells or rooms.
  2. Insufficient spacing between types or classes of apparatus.
  3. Improper grouping of equipment, wiring, etc.
  4. Improper drainage of oil, etc.

D. Poor Housekeeping
  1. Rubbish during construction
  2. Accumulation of rubbish in operation.
  3. Storage of inflammable material.

E. Fanning Action of Ventilating Equipment.
F. Lack of fire Extinguishing Apparatus.
G. Failure to Announce Start of Fire, Smoke or Heat.

III—Preventive Measures

A. Use of fire-proof or fire-resisting material in construction.
B. Elimination of oil so far as possible.
C. Keeping premises and apparatus clean.
D. Segregation of apparatus.
E. Correct design or application.
F. Constant expert supervision.
G. Careful inspection before and during installation.
H. Periodic testing.

IV—Extinguishing of Fires

A. Detection.
B. Alarms.
C. Accessibility.
D. Automatic fire extinguishers—classification and suitability of each type.
E. Hand-operated extinguishers—classification and suitability of each type.
F. Drainage of burning oil.

WIRE DESIGNATIONS

Contributed by O. J. Rotty and M. E. Reagan.

The development of a uniform scheme of wire designations for station control wiring has been given some study with the idea that if a satisfactory scheme could be devised it should be offered for standardization.

The general use of such a scheme would produce uniform marking of control wiring at all stations regardless of whether the panels were wired by different manufacturers or by the user himself. This seems desirable for many reasons. The engineer laying out a new station or an extension to an old one would have to be familiar with only one scheme of wire designations and if the apparatus for a particular station was supplied by a number of manufacturers the wire designations would be alike for all the apparatus, resulting in simplification of interconnecting wires and common circuits. These points are also of importance to the construction or installation men, to the testing men, maintenance men, trouble shooters, etc.

At present there are many schemes in use, with each manufacturer and many utilities and engineering organizations having their own schemes all of which are different although some may have certain features in common. There seem to be many reasons why each scheme is preferred by its sponsor and why other schemes are objectionable. However, it is felt that a scheme can be devised which will fulfill practically all requirements and overcome the more important objections. The standard scheme must be of a general nature and must be applicable to all kinds of stations; *viz.*, railway, Edison, mining, hydro, a-c. distribution, and even steam plants.

There is a number of points in the designation of wires on which there is fairly general agreement. These are briefly as follows: 1. The scheme should be simple, easily understood and applied and with few special cases or exceptions; 2. it should be flexible so as to permit of additions or changes to the control without completely revising the existing designations; 3. it should provide the "tie-in" with or reference between the actual wire and the diagrams (either the wiring diagram, the schematic diagram, or both); 4. the wire designations should appear on the schematic (or elementary) diagram.

It also seems desirable that certain other ideas be worked into the standard scheme, which are briefly as follows: 1. The wire designation should be made up of as few digits as possible; 2. it should not be a complicated combination of letters and numbers; 3. it should preferably have some significance as to the apparatus or panel the wire connects to, although this appears to be difficult to devise and very likely an arbitrary scheme will be finally adopted; 4. operating and control buses and circuits of the nature of buses should be included in the standard scheme.

This subject has been taken up by this committee only recently and the time has been insufficient for the development of a finished scheme. However, it is felt that the work should be continued by the succeeding committee.

Several closely allied subjects have presented themselves for investigation but lack of time has prevented work upon them. They are: 1 Wire group or conduit designations or numbers, and 2, wire color codes. It is felt that these should also be given some study with a view to suggesting standards for them.

RESEARCH

Contributed by M. E. Reagan.

Research items to be studied and followed by the committee are divided under four main divisions. One object of investigation is to assemble data on operation while another object is to establish the trend of automatic expansion in operation. For instance, in the use of vacuum gas filled tubes in power and control systems, it will be the function of this committee to carefully record the various applications and keep experience charts showing the growth of usefulness and their performance.

The four general classifications are as follows:

I. Automatic Control of Rotating Machines (including mercury arc rectifiers).
  a. Synchronous converters.
  b. Motor-generator sets.
  c. Mercury-arc rectifiers.
  d. Hydro-electric generators.
  e. Frequency-changers.
  f. Synchronous condensers.
  g. Balancer sets.
  h. Battery chargers
    1. Automatic end cell switches.
II. Automatic Control of Static Machines.
  a. A-c. transformer substations.
  b. Periodic reclosing feeders.
  c. Static condensers.
III. Network Protectors.
IV. Supervisory Control.
  a. Terminal apparatus.
  b. Channels.
    1. Fused lines.
    2. Private.
    3. Carrier, etc

Suggested Items.
  a. Curve of total installations by years.
  b. Curve of total kva. by years.
  c. Curve of per cent automatic to manual installation by years.
  d. Curve showing rehabilitation of old units for automatic service.
  e. Curve showing per cent availability by years.
  f. Data on primary causes of outages, such as
    1. Line trouble.
    2. Main apparatus trouble.
    3. Control trouble.
    4. Due to testers or maintenance man.
  g. Performance data on fuses in control circuits.
  h. Ventilation as it affects "sweating" of apparatus.
  i. General field testing of equipment expand last year's report.
  j. Data on vacuum tube applications of all types in control work.

TELEMETERING IN CONNECTION WITH LOAD DISPATCHING

Contributed by A. M. Garrett and J. J. Samson.

In order that electrical systems, particularly those of the public utility and traction companies, function with the highest degree of service standard and efficiency, it is necessary that the control of certain system operations be centralized.

Such operating knowledge and duties as restoration of the service to normal during or following a case of system trouble; the interchange of energy between systems or parts of the same system; switching in and out of service of generating station or substation units in accordance with load demands; the load quantities existing in different parts of the system; the maintenance of proper voltage, frequency, temperature of equipment; adjusting the system to take care of construction work in connection with system extensions, maintenance and repairs, are some of the functions that must come under the guidance of this group.

The majority of these functions is under the control of the load dispatcher or system operator who depends upon his knowledge of the operating condition of the system through the forces which actually operate it. This information comes to him in the nature of a periodic check, generally by telephone.

In recent years as the system developed through growth and expansion, and in some instances through combination, the problems associated with the handling of these systems become more involved, so that the need for quicker and more accurate information as to the operating status of the system became apparent. In order to handle the situation intelligently, a continuous record or "running account" so to speak was needed instead of a periodic sampling of conditions. To meet these requirements telemetering or remote indication equipment has been developed and placed in service in many systems in this country in the past five years. To take care of these problems under the old method would mean quite a material increase in the load dispatchers' force.

Telemetering is a means of transmitting to a central control point over a communicating circuit or special conductors, information necessary for the operation of the equipment, station or system. This may be electrical quantities (volts, amperes, watts, power factor), temperature, position of breakers, regulators, or any other information that it may be desired to obtain from the system.

It consists essentially of a transmitter at the remote end connected to the equipment from which information is desired, a receiver at the control end and the connecting circuit. The quantity of energy to be measured or position of equipment to be indicated is converted to a voltage and current (suitable for telephone cable) whose value is proportional and is transmitted to the receiver which is calibrated to record the information.

With a view to determining the trend of telemetering devices and methods, the committee decided that a survey in the form of a questionnaire should be made of those companies now operating this class of equipment. The questionnaire covered the following points:

1. What of the following do you use telemetering for?
   Totalizing load.
   Current and voltage conditions.
   Temperature of equipment.
   Position of switch gear.
   Tap changer and regulator positions.
   Uses other than above.
2. State briefly the type of system and the principles of operation.
3. What channels are used?
   Telephone lines.
   Transmission lines.
   Special conductors.
   State approximate distances of transmission.
4. Is this system of aid in load dispatching?
   In what manner?
5. What criticism do you have of telemetering?
6. What, in your opinion, is the trend of development?

The term "load dispatching" is understood to cover broadly the function of load control and switching operation which is dependent upon telemetering information.

This survey has just been completed and a total of 35 companies canvassed. The following information has been compiled:

Under uses or application we found approximately 40 per cent of the companies use the equipment for determination of current and voltage conditions, while 22 per cent of the installations were for totalizing load and 18 per cent were for position indication of equipment.

Under types used, there seems to be a general use of direct current either in the form of balanced current or rectified current.

As the connecting circuit between the remote end and the receiving end, about 30 per cent used active telephone circuits, while the remaining 60 per cent used special conductors. The distance of transmission varies from 500 feet to 15 miles with no special average.

In answer to the direct question of whether the system was an aid in load dispatching, 60 per cent stated that it was, while the rest of the replies gave no opinion or indicated lack of experience due to the short time the equipment had been in service.

In reply to the inquiry on criticism of the equipment, the survey showed little or no adverse expression. One point emphasized was the lack of high speed response with accuracy comparable to the usual line of switchboard indicating instruments. There is a tendency where high speed is desired to sacrifice somewhat the matter of accuracy. Another criticism was on the cost basis, the installed cost of the equipment running into "considerable money." Especially is this true where special conductors are required over long transmitting distances.

Improvements toward simplification of the present complicated equipment, as means to greater reliability, was offered as one criticism.

On trend of development, practically all replies indicated a favorable reaction to future development, especially where extension to the system was in prospect. This applies particularly to the situation where interconnection is concerned. One reply mentioned there would be no future development for telemetering in this company as the type of distribution was being changed to an a-c. network whereby the substation would be eliminated.

In general, it can be stated that telemetering has established itself, and with extension of load control and switching operations made necessary through an increase in the size of systems, in interconnection between systems, and constantly increasing number of unattended stations, telemetering is proving a distinct aid in the solution of those problems of handling and operating an electric system.

Supplemental Bibliography

Contributed by Main Library of the General Electric Company

1931

Armstrong, H. V., "Automatic Substations Installed by Windsor, Essex & Lake Shore Railway," *Elec. Traction*, Vol. 27, pp. 36-38, Jan. 1931.

Colonna, O., "Remote Transmission of Measured Values." (In Italian.) *Elettrotecnica*, Vol. 18, pp. 32-36, Jan. 15, 1931. Siemens apparatus and methods.

Fleck, B., "Hydroelectric Plants without Attendants." (In German.) *AEG. Mit.*, pp. 55-64, Feb. 1931.

Geyger, W., "New Rotating Iron 'Quotient Meter' for Alternating Current, and Its Application in the Supervision of Therman Processes." (In German.) *Arch. fur Elek.*, Vol. 25, pp. 1-16, No. 1, 1931.

Kerr, S. L., "Automatic Operator for Economy Control." *Elec. Engg.*, Vol 50, pp. 14-17, Jan. 1931. *Power*, Vol. 72, pp. 698-99, Oct. 28, 1930. Abstract.

Kloninger, H. C., "Control Centers for Electric Generating and Distributing Installations." (In French.) *Soc. Belge des Elec. Bul.*, Vol. 47, pp. 1-14, Jan. 1931. Serial.

Kotschubey, N., "Mercury-Arc Rectifier Plants of the New South Wales Government Railways and Tramways, Sydney, Australia," *Brown Boveri Rev.*, Vol. 18, pp. 103-7, Feb. 1931.

Liston, J., "Developments in the Electrical Industry 1930; Railway Substations," *G. E. Rev.*, Vol. 34, p. 22, Jan. 1931.

Meiners, G., "Application of Automatic Operation in Power Engineering." (In German.) *AEG. Mit.*, pp. 16-28, Jan. 1931.

Moreland, E. L., "Lackawanna Electrification Improves Suburban Service," *Elec. Engg.*, Vol. 50, pp. 185-92, Mar. 1931. "Bernardsville Automatic Substation," pp. 186-88.

Stanley, R. M. and Wood, E. D., "Control Groups Simplify Operation," *Elec. Engg.*, Vol. 50, pp. 128-32, Feb. 1931. Includes a description of the supervision equipment of the Ohio Falls hydro station.

Traill, J. J. and Seymour, N. F., "Small Automatic Plant Contributes 1,800 Hp. to Nipissing System," *Elec. News & Engg.*, Vol. 40, pp. 35-38, Mar. 1, 1931. Elliott Chute development.

Anonymous. "Altrincham Electrification," *Elec. Rev.*, Lond., Vol. 108, pp. 136-38, Jan. 28, 1931. *Elec'n.*, Lond., Vol. 106, pp. 136-37, Jan. 23, 1931.

"Automatic and Partially Automatic Hydro Operation Shows Definite Increase," *Elec. Wld.*, Vol. 97, p. 184, Jan. 24, 1931.

"Distant Reading Hydraulic Gauges," *Engg.*, Lond., Vol. 131, pp. 92-93, Jan. 16, 1931.

"Empire Operating Automatic Station," *Oil & Gas Jour.*, Vol. 29, pp. 24-25, Jan. 22, 1931.

"Remote Control Transport System Saves Labor and Power, Trinity Portland Cement Plant, Dallas," *Engg. & Min. Jour.*, Vol. 131, p. 10, Jan. 12, 1931.

1930

Ambuhl, F. F., "Modernizing Canada's First Automatic Station," *Elec. News & Engg.*, Vol. 39, pp. 37-38, 48, Nov. 15, 1930. Ossington Station of the Toronto Hydro-electric System.

American Institute of Electrical Engineers, Automatic Stations. Annual report of the Committee on Automatic Stations. A. I. E. E. Quar. Trans., Vol. 49, pp. 1660-70, Oct. 1930. Includes a bibliography for 1929-1930. A. I. E. E. Jour., Vol. 49, pp. 612-20, Aug. 1930.

Angelis, M. L. de, "Montreal Tramways Installs Third Automatic Rectifier Substation; Viau Substation," *Elec. Rwy. Jour.*, Vol. 74, pp. 577-80, Sept. 1930.

Angelis, M. L. de, "Montreal's Third Automatic Mercury Arc Railway Substation," *Elec. News & Engg.*, Vol. 39, pp. 53-56, Sept. 15, 1930.

Armstrong, H. V., "Design and Operation of the Windsor, Essex and Lake Shore Railway Automatic Substations," *Elec. News & Engg.*, Vol. 39, pp. 31-34, Nov. 1, 1930.

Armstrong, H. V., "Windsor, Essex and Lake Shore Railway Automatic Substations," *Bul. of Hydroelec. Power Commission of Ont.*, Vol. 17, pp. 325-32, Sept. 1930.

d'Audeville, P., "Automatic Generating Stations and Substations." (In French.) *Soc. Fr. des Elec. Bul.*, Vol. 10, pp. 732-64, July 1930. Advantages, methods of operation, economics, descriptions of installations, etc.

Bale, L. D., "Increased Power Department Responsibility Demands Proper Equipment and Practices," *Elec. Rwy. Jour.*, Vol. 74, pp. 412-15, June 14, 1930.

Baugh, C. E. and Garrett, P. B., "Automatizing High-Voltage Transmission; Morgan Hill Substation of the Pacific Gas & Electric Co.," *Elec. West*, Vol. 64, p. 178-81, Apr. 1930.

Becker, J., "Remote Measuring by the Impulse Frequency Method," *Engg. Progress*, Vol. 11, pp. 161-65, June 1930.

Beschnitt, A. and Müller, K., "New Remote Control for High-Voltage Oil Switches." (In German.) *Bergmann Mit.*, Vol. 8, pp. 95-100, May-June 1930.

Blamberg, E., "Summation with Cross-Coil Ohmmeters." (In German.) *Arch. fur Elek.*, Vol. 24, pp. 21-28, No. 1, 1930.

Brackinreid, T. W., "Automatic and Remote Control for Substation," *Elec. Traction*, Vol. 26, pp. 483-84, Sept. 1930.

Brückel, W. and Stäblein, W., "Progress in Remote Measuring." (In German.) *AEG. Mit.*, pp. 185-90, Mar. 1930. *Elec. und Masch.* Vol. 48, pp. 191-94, Mar. 2, 1930.

Cissna, L. J., "Miniature Remote Control Switchboards," *Elec. Jour.*, Vol. 27, pp. 689-95, Dec. 1930.

Clough, F. H., "Remote Metering." World Power Conference (Second), Paper No. 91, Berlin, 1930. British practise.

Colvin, C. W., "Automatic Hydro-Electric Plant Proves Its Economies," *Elec. West*, Vol. 64, pp. 128-29, Mar. 1, 1930. Alouette plant of the British Columbia Electric Railway Co.

Cook, H. D., "Automatic Hydroelectric Stations in Australia." World Power Conference (Second) Paper No. 94. Berlin, 1930.

Courcier, J., "Bazancourt Automatic Hydroelectric Plant." (In French.) *Rev. d'Elec. & de Mec.*, pp. 40-44, July-Aug. 1930. Description of a 160-kva. plant in France.

Desloover, J. R., "Burroughs Falls," *Elec. News & Engg.*, Vol. 39, pp. 31-34, Apr. 1, 1930. New 2,000-Kva. Automatic Plant of Southern Canada Power in Quebec.

Dessus, M., "Importance of Central Control Points for Boilers and Station Auxiliaries." World Power Conference (Second) Paper No. 202. Berlin. 1930.

Dourche, L., "Bergerie Automatic Substation of the Société d'Eclairage Electrique at Cannes." (In French.) *Rev. Gen. de l'Elec.*, Vol. 28, pp. 823-34, Nov. 22, 1930.

Erényi, G., "Remote Control of Induction Regulators," *AEG. Progress*, Vol. 6, pp. 134-37, Apr. 1930.

Falcke, J., "Centralized Control System of the Victoria Falls and Transvaal Power Company, Limited," *South Afr. I. E. E. Trans.*, Vol. 21, pp. 105-15, May 1930.

Fischer, W. and Pungs, L., "Control of Switching Operations by the Use of Electron Tubes." (In German.) *Zeits. Hochfrequenz.*, Vol. 35, pp. 205-12, June 1930.

Fitzgerald, A. S., "Electron Tube Telemetering System," A. I. E. E. Jour., Vol. 49, pp. 513-16, July 1930. *Elec. Wld.*, Vol. 96, pp. 29-30, July 5, 1930. Abstract. A. I. E. E. Quar. Trans., Vol. 49, pp. 1321-38, Oct. 1930.

Fox, H. K., "Semi-Automatic Hydro Plant Utilizes Variable Flow," *Elec. Wld.*, Vol. 96, pp. 991-93, Nov. 29, 1930. Merced Falls plant of the San Joaquin Light and Power Corporation.

Franca, L., "Inauguration of the First Automatic Hydroelectric Station in Brazil," *Digest*, Vol. 10, pp. 5-8, Oct. 1930.

Garrett, P. B., "Supervisory Control Sets a Record," *Elec. Jour.*, Vol. 27, pp. 319-22, June 1930.

Garvin, J. P., "Miniature Remote Control Extends the Maximum Economical Distance Between Generating Plant and Substation," *Elec. Jour.*, Vol. 27, pp. 327-29, June 1930.

Geiselman, R. A., "Automatic Frequency and Load Control," *Elec. Jour.*, Vol. 27, pp. 579-80, Oct. 1930.

Gouger, B., "Supervisory for San Antonio," *Elec. Wld.*, Vol. 96, pp. 1166-69, Dec. 27, 1930.

Gutzwiller, W. E. and Naef, O., *1,000-Kw. Automatic Mercury-Arc Rectifier Substation of the Union Railway Company of New York*, A. I. E. E. Jour., Vol. 49, pp. 528-31, July 1930. *Elec. Wld.*, Vol. 96, p. 29, July 5, 1930. Abstract. A. I. E. E. Quar. Trans., Vol. 49, pp. 1357-62, Oct. 1930.

Harry, R. J., *Automatic Power Supply for Steel Mill Electrification; Monongahela Valley System of the Carnegie Steel Co*, A. I. E. E. Jour., Vol. 49, pp. 445-48, June 1930, A. I. E. E. Quar. Trans., Vol. 49, pp. 1351-56, Oct. 1930.

Harry, R. J., "Carnegie Steel Co. Substation," *Elec. Wld.*, Vol. 96, pp. 28-29, July 5, 1930. Abstract.

Harvey, R. M., "Supervisory Control of Unattended Substations," *Elec. Engr. of Austr. & N. Z.*, Vol. 7, pp. 121-27, July 15, 1930.

Janicki, W., "Latest Developments in Electric Metering Especially Remote Integrating Measurements." (In Dutch.) *Electrotechniek*, Vol. 8, pp. 377-82, Oct. 29, 1930.

Janicki, W., "Remote Indicating and Remote Integrating Measurements in the Operation of Power Plants." (In German.) *Schweiz. Elek. Ver. Bul.*, Vol. 21, pp. 117-36, No. 4, 1930.

Janicki, W., "Telemetering in the Electrical Industry," World Power Conference (Second), Paper No. 209. Berlin, 1930. Swiss practise.

Jones, D. M., "Controlling Load; Maintaining Frequency; Modern Systems Including the Warren Telechron," *Elec. Wld.*, Vol. 95, pp. 1072-76, May 31, 1930.

Kerr, S. L., "Automatic Operator for Economy Control Applied to Hydroelectric Generating Stations," *Power*, Vol. 72, pp. 698-99, Oct. 28, 1930.

Kerr, S. L., "Frequency and Load Control on Electric Systems," *Power Plant Engg.*, Vol. 34, pp. 682-85, June 15, 1930.

Köberlich, R., "Progress In Remote Control and Remote Signaling." (In German.) *AEG. Mit.*, pp. 537-43, Aug. 1930.

Langlois, S., "Uriage and Vizille Automatic Substations of the Dauphiné Railways." (In French.) *Rev. d'Elec. & De Mec.*, pp. 33-42, May-June 1930.

Laun, F., "Automatic Railway Substations," *AEG. Progress*, Vol. 6, pp. 231-36, July 1930.

Lawson, J. T., *Centralized Control of System Operation; Public Service Electric and Gas Company in New Jersey*, A. I. E. E. Jour., Vol. 49, pp. 425-28, June 1930. A. I. E. E. Quar. Trans., Vol. 49, pp. 1344-50, Oct. 1930.

Lebrecht, L., "Hosterwitz Completely-Automatic Remote-Controlled Glass Rectifier Substation." (In German.) *AEG. Mit.*, pp. 709-13, Nov. 1930.

Lichtenberg, C. and Wensley, R. J., "Automatic Stations and Their Remote Supervision," World Power Conference (Second), Paper No. 261. Berlin, 1930.

Littlewood, H. S., "Automatic Switching; Mining Service Demands for Greater Safety, Lower Costs and Better Production Methods," *Elec. Jour.*, Vol. 27, pp. 252-56, May 1930.

Marshall, C. W., "Metering Arrangements for the 'Grid' Transmission System in Great Britain," *I. E. E. Jour.*, Vol. 68, pp. 1497-1506, Nov. 1930.

Meunier, R. W., "Riedji Automatic Hydroelectric Plant." (In French.) *Rev. Gen. de l'Elec.*, Vol. 28, pp. 781-85, Nov. 15, 1930. Description of a Swiss plant.

Monroe, R. W. and Littlewood, H. S., "Changing Manually-Operated Substation to Automatic; Consolidation Coal Company, Somerset, Pa.," *Elec. Jour.*, Vol. 27, pp. 515-19, Sept. 1930.

Mülinen, E. de, "Brown Boveri Remote Supervisory Control with Stationary Selectors," *Brown Boveri Rev.*, Vol. 17, pp. 285-92, Sept. 1930.

Nash, F. M., "Automatic Operator a Success; Norwood Hydro-Electric Plant, Mount Gilead, N. C.," *Elec. Wld.*, Vol. 96, pp. 342-46, Aug. 23, 1930.

National Electric Light Association, "Automatic and Partial Automatic Hydroelectric Plants," *N. E. L. A. Proc.*, Vol. 87, pp. 557-75, 1930.

Paden, R. S., "Series Lighting Loop Controls Substation Circuits," *Elec. Wld.*, Vol. 95, p. 835, Apr. 26, 1930.

Paschen, P., "New Meters for Totalizing and Remote Measurement of Electric Power," (In German.) *Siemens-Zeits.*, Vol. 10, pp. 110-14, Feb. 1930.

Pascher, A. and Zink, G., "München-Haidhausen Automatic Rectifier Station." (In German.) *AEG. Mit.*, pp. 299-304, Apr. 1930.

Pausert, T., "Control Room for the Remote Control of Boiler Firing in the Issy-les Moulineaux Power Plant." (In French.) *Rev. Gen. de l'Elec.*, Vol. 28, pp. 949-63, Dec. 13, 1930.

Pitts, C. R., "Automatic Throw-Over Equipment for Emergency Service," *Power*, Vol. 71, pp. 675-76, Apr. 29, 1930.

Probst, H., "Considerations in the Arrangement of Measuring, Control and Signal Apparatus in the Control Rooms of Power Stations." (In German.) *AEG. Mit.*, pp. 124-33. Sup. June 1930.

Probst, H., "Switchgear Including Automatic Control Apparatus for Power Stations and Remote Metering and Signaling Apparatus." World Power Conference (Second), General Reports, Section 19, pp. 135-47. Berlin. 1930. General survey of the papers presented on the subject.

Rickards, C. S. and Canning, D. V., "Complete Automatic Hydro-Electric System," *Elec. News & Engg.*, Vol. 39, pp. 31-32, 36, Sept. 1, 1930. Plants of the Nova Scotia Power Commission on the Mersey River.

Ricker, H. A. and Others, *Vertical Shaft 25,000-Kva., Synchronous Condensers for Toronto Leaside Transformer Station*, A. I. E. E. Jour., Vol. 49, pp. 517-19, July 1930. *Power*, Vol. 72, pp. 32-33, July 1930.

Schaubel, E. H., "Modernizing the D-C. Power System of the Northwestern Pacific Railroad," *G. E. Rev.*, Vol. 33, pp. 540-44, Oct. 1930.

Schleicher, M. and Others, "Automatic Operation of Power Plants and Substations and Recent Telemetering Practice," (In German.) World Power Conference, (Second), Paper No. 40. Berlin. 1930. With special reference to German practise.

Schleicher, M., "Modern Methods of Controlling the Exchange of Energy." (In German.) *Siemens-Zeits.*, Vol. 10, pp. 352-54, June 1930.

Siegfried, J. H., "Dispatcher's Board Uses Electrically Operated Targets," *Elec. Wld.*, Vol. 95, p. 981, May 17, 1930.

Soldati, E., "Riedji Automatic Hydro-Electric Power Station of the Elektrizitätswerke Lonza A. G., Basle," *Brown Boveri Rev.*, Vol. 17, pp. 253-57, Aug. 1930.

Sporn, P., *Miniature Switchboards*, A. I. E. E. Quar. Trans., Vol. 49, pp. 1363-69, Oct. 1930.

Stivender, E. H., "Automatic Control of Hydroelectric Stations by the All Relay System; Doris Lake Plant, near Sargent, Nebraska," *Power Plant Engg.*, Vol. 34, pp. 755-57, 810-13, 982-85, July 1-15, Sept. 1, 1930.

Täuber-Gretler, A., "Trüb, Täuber & Company's System of Remote Electric Indicating and Integrating." (In German.) *Schweiz. Elek. Ver. Bul.*, Vol. 21, pp. 144-45, No. 4, 1930.

Wensley, R. J. and Donovan, W. M., *Development of a Two-Wire Supervisory Control System with Remote Metering*, A. I. E. E. Jour., Vol. 49, pp. 460-63, June 1930. A. I. E. E. Quar. Trans., Vol. 49, pp. 1339-43, Oct. 1930.

Wensley, R. J. and Donovan, W. M., "Two-Wire Supervisory Control System," *Elec. Wld.*, Vol. 96, p. 30, July 5, 1930.

Whitman, K. E., "New Nova Scotia Plant Equipped with Automatic Turbines," *Elec. News & Engg.*, Vol. 39, pp. 31-34, 44, July 1, 1930. Tusket Falls plant of the Nova Scotia Power Commission.

Wollner, W. S., "Power Improvements Increase Speed of Trains; Northwestern Pacific Railroad Electric Suburban Service," *Elec. Traction*, Vol. 26, pp. 225-27, May 1930.

Anonymous. "A. E. G. Compensation Telemetering System and Its Applications." (In German.) *AEG. Mit.*, pp. 412-15, June 1930.

"Adapting Radio Parts to Automatic Substations," *Elec. Wld.*, Vol. 96, p. 225, Aug. 2, 1930.

"Automatic Control for Stand-By Plants," *Power Plant Engg.*, Vol. 34, pp. 1155-57, Oct. 15, 1930.

"Automatic Control of Hydro Plants; Developments on the Mersey River, Nova Scotia," *Can. Engr.*, Vol. 59, pp. 579-81, Oct. 28, 1930.

"Automatic Frequency Control in Hydro-Electric Plants; Pacific Coast Electrical Association Committee Report," *Elec. West*, Vol. 64, pp. 337-54, May 15, 1930.

"Automatic Hydraulic Regulatory and Safety Devices, Pacific Coast Electrical Association Committee Report," *Elec. West*, Vol. 64, pp. 331-54, May 15, 1930.

"Automatic Hydroelectric Installation; Tizcapa Power Station of the Mexican Light and Power Co.," *Elec. Rev.*, Lond., Vol. 107, pp. 317-18, Aug. 22, 1930.

"Automatic Hydroelectric Plants." (In Italian.) *Bolletino Tecnico*, Vol. 3, pp. 4-20, Apr. 1930. General review of the necessary equipment.

"Automatic Remote Control; Sugarloaf-Rubicon Scheme, Victoria," *Elec'n.*, Lond., Vol. 105, p. 169, Aug. 8, 1930.

"Automatic Substations," *Elec'n.*, Lond., Vol. 105, pp. 750-51, Dec. 12, 1930.

"Automatic Substations for Japan," *Engr.*, Lond., Vol. 149, p. 322, Mar. 21, 1930. *Elec. Rev.*, Lond., Vol. 106, pp. 564-65, Mar. 21, 1930. *Elec'n.*, Lond., Vol. 104, p. 325, Mar. 14, 1930.

"Automatic Substations; Interesting Equipment in the Southend District," *Elec'n.*, Lond., Vol. 105, pp. 750-51, Dec. 12, 1930.

"Automatic Time-Cycle Contactors," *Am. Mach.*, Vol. 73, p. 985, Dec. 18, 1930.

"Changes in Omaha Power System Result in Large Economies; Omaha and Council Bluffs Street Railway Co.," *Elec. Traction*, Vol. 26, pp. 566-68, Nov. 1930.

"Control of Substations," *Elec'n.*, Lond., Vol. 105, pp. 145-46, Aug. 1, 1930. Supervisory system for the Central Argentina Railway.

"Controlling Remote Electric Equipment by Audio-Frequency Impulses," *Power*, Vol. 72, p. 907, Dec. 2, 1930.

"Developments at Douglas, I. O. M., Mercury-Arc Automatically Operated Rectifier Substations," *Elec. Rev.*, Lond., Vol. 106, pp. 845-46, May 2, 1930.

"Distant Metering; the Midworth Distant Repeater," *Wld. Power*, Vol. 14, p. 228-30, 233, Sept. 1930.

"Mercury Arc Rectifier Equipment for the Melbourne Tramways," *Engr.*, Lond., Vol. 150, pp. 655-56, Dec. 12, 1930. Equipped for automatic control.

"N. E. L. A. Committee Considers Problems of Governing Hydroelectric Units and of Applying Autom tic Frequency Control," *Power*, Vol. 71, pp. 486-87, Mar. 25, 1930.

"New Remote Indicator," (In German.) *AEG. Zeitung*, pp. 6-8, Jan. 1930.

"Power Possibilities of Catawba River Highly Developed Through Stream Control; Duke Power Co.," *Engg. News-Rec.*, Vol. 104, pp. 1007-12, June 19, 1930.

"Remote Control at Muskoka Hydro Plant," *Can. Engr.*, Vol. 59, pp. 111-12, July 1, 1930.

"Semi-Automatic Water Power Stations," *A. S. E. A. Jour.*, Vol. 7, pp. 58-65, May 1930.

"Supervisory Control; Equipment for the Auckland Electric Power Board, New Zealand," *Elec'n.*, Lond., Vol. 105, pp. 556-57, Nov. 7, 1930.

"Supervisory Control of Substations; Central Argentine Railway," *Elec. Rev.*, Lond., Vol. 107, pp. 1104-5, Dec. 26, 1930. Metropolitan-Vickers equipment.

"Supervisory Control of Sub-Stations on the Central Argentine Railway," *Rwy. Gaz.*, Vol. 53, pp. 336-38, Sept. 12, 1930.

1929

Blet, J., "Remote Control and Regulation of Hydroelectric Plants." (In French.) *Genie Civil*, Vol. 95, pp. 533-36, Nov. 30, 1929.

Lichtenberg, C. and Zogbaum, F., "Remote Operating Supervision and Control of Electric Power Stations and Substations in the United States," World Engg. Congress, Tokyo. 1929.

Schleicher, M., "Electric Remote Measurements for Electric Power Plant Operation." (In German.) *Siemens Jahrbuch*, pp. 409-20. 1929.

Communication

ANNUAL REPORT OF THE COMMITTEE ON COMMUNICATION*

IN accordance with the usual practise, this committee submits herewith a brief review of the developments during 1930 in electrical communication.

TELEPHONE SERVICE IMPROVEMENTS

Telephone service was improved during the year by the application of new developments and methods and improved maintenance. The average time to complete toll calls was lowered by 12 seconds to an average of one minute. Improved maintenance methods have reduced the frequency of troubles affecting subscribers' lines so that a trouble now occurs on the average but once in 22 months, a reduction in trouble frequency of about 11 per cent as compared with 1929.

Steady advancement in the quality of speech transmission was accomplished. On the longer haul toll business, unsatisfactory transmission conditions were experienced on only 1.5 per cent of the messages, compared with 1.7 per cent in 1929. One of the important factors contributing to this improvement was the institution of a more effective method for controlling the amplification of speech on toll calls involving two or more long circuits. An improved general plan for the design and rearrangement of plant to handle calls between remote points not connected by direct circuits was adopted. Under this plan, the number of intermediate switches is minimized with a consequent improvement in speed, accuracy, directness of routing, and transmission. A paper describing this plan, by Mr. H. S. Osborne, was presented at the 1930 Summer Convention. (A. I. E. E. TRANS., October 1930.)

SUBSCRIBER'S EQUIPMENT AND SERVICES

During 1930 the number of hand telephone sets in service increased to approximately 2,000,000 as against about 1,000,000 at the beginning of the year. The development of a type of hand set which would meet the electric and acoustic requirements of telephone practise in this country has involved the solution of difficult technical problems. These problems have been concerned primarily with the suppression of singing, for which the hand set has a tendency because of the rigid connection of the transmitter and receiver, and with the efficient operation of the transmitter in a wide range of angular positions. These difficulties have been successfully overcome through the application of a large amount of scientific work in the design of the hand set handle, the transmitting and receiving elements, and the electrical circuit connecting them. These achievements have made it possible to use the hand set without any sacrifice in performance as compared with the desk stand set.

For subscribers requiring a large number of attendants to take messages or orders, there has been made available an automatic call distributing arrangement associated with a simple type of attendant's position, whereby calls are immediately connected to idle attendants or, if none are available, are held and subsequently connected in the order in which they arrived.

A new type of private branch exchange suitable for larger residences and business offices of moderate size was made available during the year. No operator or attendant is required. Calls may be originated, answered, and transferred from any of the telephones. Intercommunicating calls are made by means of the dial. Complete privacy for both outside and intercommunicating connections is provided.

While arrangements have been available for some time for private branch exchanges whereby a number of telephones could be connected together simultaneously in a conference connection, these arrangements have been extended during the past year so as to enable the interconnection of a larger number of stations and to include more than one trunk circuit out of the private branch exchange.

CENTRAL OFFICE SYSTEMS AND APPARATUS

During 1930 there was an increase of about 1,000,000 dial stations, bringing the total to approximately 5,565,000, or more than one-fourth of the total number of stations in this country. Besides the conversion to dial of additional portions of large cities, increasing use has been made of dial equipment in small communities where services requiring the assistance of operators can economically be handled from near-by centers.

Further extensions have been made in the mechanical tandem facilities used primarily for service between the larger areas and neighboring suburban points. Arrangements are now in service for automatically inserting voice repeaters when required on calls between the more distant points. Facilities are also included for completing calls to a variety of types of offices, either mechanically or by key sets at call distributing tandem positions. An installation of call announcer apparatus, described in last year's report, has been made in New York. The mechanical tandem also includes a trouble recorder which provides a continuous count of calls affected by various classes of irregularities and prints, by means of a teletypewriter, a complete record of the channels and equipment used by such calls.

---

*COMMITTEE ON COMMUNICATION:

G. A. Kositzky, Chairman,
H. M. Bascom,
G. R. Benjamin,
B. K. Boyce,
A. F. Brooks,
W. H. Capen,
J. L. Clarke,
R. N. Conwell,
C. F. Craig,
B. R. Cummings,
H. W. Drake,
R. D. Evans,
C. E. Fleager,
D. H. Gage,
S. P. Grace,
Erich Hausmann,
H. L. Huber,
C. F. King, Jr.,
R. H. Manson,
John Mills,
J. W. Milnor,
J. L. Niesse,
H. S. Osborne,
F. A. Raymond,
H. A. Shepard,
H. S. Sheppard,
A. N. Symes,
H. M. Turner,
F. A. Wolff.

The panel system has been provided with a new type of equipment known as the decoder for translating the digits dialed by the subscriber into the electrical information required for routing the call to various types of offices. Panel equipment in certain areas is also being arranged to permit subscribers to dial calls directly to distant zones which previously required the supervision of an operator because of the additional charges involved. The equipment is arranged to determine the number of message units corresponding to the charge to the zone in which the call terminates and to cause a corresponding number of operations of the message register.

Time announcement systems for use in the larger areas have been modified by the addition of facilities for the distribution of announcements over a trunk network, equipped with repeaters to insure adequate volume and quality, so that one operator may furnish time announcements for a network of offices.

An improved low-speed interrupter, utilizing mercury make and break contacts, has been developed for use in giving flashing signals to operators and in timing sequence operations. For producing tones used as signals to operators and subscribers, there has been developed an alternator which enables close control of the frequency, magnitude, and harmonic content of the tones. The field windings and the tone output windings of this alternator are formed on the stator, and the tone is produced by an unwound, toothed rotor which varies the magnetic flux in the tone windings.

Privacy apparatus was put into service during the year on nearly all of the intercontinental radio telephone circuits operated out of this country. By means of this apparatus the radio waves transmitting conversations are so modified in their characteristics that if listened to with an ordinary radio set, speech is not intelligible. At the receiving end this process is reversed and intelligible speech restored. While this does not guarantee complete secrecy, it does furnish a considerable degree of privacy and represents an important step in advance.

Another important toll equipment development was a new type of toll switchboard in which the use of smaller jacks makes possible a substantial increase in the number of trunks and toll lines appearing at each toll operator's position. Tandem positions are also provided through which an operator may secure access to any circuit not appearing in the toll line multiple at her position.

OUTSIDE PLANT CONSTRUCTION AND METHODS

To facilitate the placing of tape armored toll telephone cables, a method has been developed whereby the trenching, laying of the cable, and the filling of the trench are simultaneously accomplished in one operation. This method utilizes a tractor behind which are pulled the trailer supporting the cable reel, the plow, and the drag which fills in the trench. From the reel, the cable is threaded through a pipe which leads it to the trench at a point directly in back of the plow. Under ordinary conditions it has been practicable, on the average, to lay more than one mile of cable per day with one outfit, using this method.

A new method which utilizes a single tube sleeve has been developed for making joints in aerial line wire. A hand operated rolling tool compresses the sleeve onto the wire in such a way as to provide a joint with no greater electrical resistance than a corresponding length of line wire and with a tensile strength at least equal to that of the wire. This new joint is expected to avert the electrical troubles now experienced with open-wire joints of the twisted sleeve type.

An important step has been taken by the communication interests cooperating with other pole using utilities, and others connected with the pole industry, in arriving at uniform classification dimensions for wood poles of southern yellow pine, western red cedar, northern white cedar, and chestnut. This work was carried on by the American Standards Association. Standard fiber strengths lb. per sq. in. have been established as follows: 7,400 for southern yellow pine, 5,600 for western red cedar, 3,600 for northern white cedar, and 6,000 for chestnut. These values have been accepted and made American Standards.

Under the new classification, a pole of a given class designation will have approximately the same breaking load regardless of pole length and species of timber. The adoption of the new grouping by all users of wood poles is expected to result in economies in the production and stocking of poles. The problems introduced by joint use will also be simplified as both parties to the joint use agreement will be using the same classification, whereas in the past this was seldom the case. Cost comparisons between the various species can be more easily made under the new classifications as prices may be directly compared class for class, whereas under the old tables calculations had to be made to determine the class of equivalent poles of other species of timber.

LONG DISTANCE TOLL CABLES

About 5,000 miles of cable for toll use were added to the telephone system of this country in 1930, bringing the total toll cable mileage to approximately 24,000 miles. Including the toll cable network on the Pacific Coast, which is connected with the toll cable network of the rest of the country by several individual and widely separated open-wire toll routes, there are now 129 out of 176 cities of the country having populations of 50,000 or more connected directly into the toll cable network. The fourth telephone cable between Key West and Havana was completed in January 1931. The new cable is non-loaded and employs the recently developed paragutta insulation. It is equipped with carrier telephone apparatus which now provides three telephone message circuits, as well as one d-c. telegraph circuit. Provision has been made for the addition of other telephone circuits when needed. The telephone facilities now afforded by the single new cable are equal to those furnished by the three older cables in total. This gain in efficiency is brought about by improvements in the art of cable construction, including employment of paragutta, as well as advances in the application of carrier methods using high frequencies for multiplexing.

About 35,000 miles of telephone circuit are now being regularly utilized for radio program transmission service and almost 200 radio broadcasting stations receive programs from these chains of wire circuits. Heretofore practically all of this service has been furnished by means of open wires using voice-frequency channels. However, a new type of circuit for toll cables has recently been developed which permits of transmission over long distances without material distortion of a frequency range from 50 to 8,000 cycles, at the same time transmitting a volume range of about 40 db. (energy ratio 10,000 to 1). These characteristics are desirable for the satisfactory transmission of music where the frequency and volume range requirements are much greater than in the case of speech. This new type of cable circuit is loaded at 3,000-ft. intervals and special repeaters are placed at approximately 50-mile intervals. Associated with each repeater is an attenuation equalizer and a delay equalizer, which correct for the attenuation and delay differences at different frequencies. A paper on this subject, by Messrs. A. B. Clark and C. W. Green, was presented at the 1930 Summer Convention (A. I. E. E. TRANS., October 1930, p. 1514.)

CARRIER TELEPHONE AND TELEGRAPH

During 1930 about 160,000 channel miles of carrier telephone facilities and 400,000 channel miles of carrier telegraph facilities were installed in the United States. Recent improvements of carrier circuits involve improved transposition arrangements and the introduction of 8-in. spacing of wires in place of the 12-in. spacing. This latter development permits an increase in the number of facilities obtainable from a given number of wires on a pole line.

The operation of voice-frequency carrier telegraph over the channels of high-frequency carrier telephone systems has been successfully applied. For example, each of the three two-way channels of a carrier telephone system has been filled with 12 carrier telegraph channels. Such a pair of wires accommodates a duplex d-c. telegraph circuit, an ordinary two-way message telephone circuit and 36 duplex carrier telegraph channels which if multiplexed would afford means for the transmission of about 7,500 words per minute for the telegraph facilities alone.

A paper by Mr. E. I. Green, discussing the transmission characteristics of open-wire telephone lines, and a paper by Mr. L. T. Wilson, discussing telephone line insulators, were presented at the 1930 Summer Convention. (A. I. E. E. TRANS., October 1930.)

INTERCONTINENTAL TELEPHONY

Most notable of the advances made during 1930 in the intercontinental telephone field was the opening on April 3 of service to South America. This service is provided by a short-wave radio circuit operating between the transmitting and receiving stations at Lawrenceville and Netcong, New Jersey, and corresponding stations near Buenos Aires, Argentina. The ratio portion of this circuit is 5,300 miles in length and it is therefore, the longest circuit now operating from the North American continent. The transmission characteristics of this circuit are, however, somewhat better than those of the short-wave circuits between the United States and England, due principally to the fact that the transmission path of the South American circuit is further removed than is that of the North Atlantic circuit from the polar regions and the adverse influences of magnetic storms. Furthermore, the South American circuit, running nearly along the meridian, experiences a more uniform condition as to daylight or darkness. As a result of these factors, extreme variations in transmission, which form an important problem on the east- and west-bound radio circuits, are materially reduced on this circuit.

At Buenos Aires the radio circuit connects with wire and cable circuits to more than 325,000 telephones in the Argentine Republic, Chile, and Uruguay, including the cities of Santiago and Montevideo.

Another feature of interest during the year was the establishment of radio communication between the United States and Australia by way of London. At London the transatlantic circuits are connected to a London-Sydney short-wave radio circuit, which at Sydney connects in turn with the wire network of the Australian Telephone Administration. This combined circuit is approximately 14,000 miles in length.

Four papers, discussing transoceanic telephone service in its various aspects, were presented at the 1930 Winter Convention by Messrs. T. G. Miller, Ralph Bown, A. A. Oswald, and F. A. Cowan.

By the end of 1930, many parts of the world had been linked together by radio-telephone circuits in addition to those mentioned above. Most of these circuits have one end in Europe, far ends in such distant places as Brazil, Argentina, Australia, New Zealand, Siam, Indo-China, Java, and Algiers. Not all of these circuits are yet connected with the telephone systems at their terminals, and they do not all, therefore, possess to the same degree the universal accessibility and utility of those radiating from North America.

SHIP-TO-SHORE RADIO-TELEPHONE SYSTEMS

A novel type of ship-to-shore service was inaugurated in the middle of the year through the equipment with radio-telephone apparatus of a New York City fire-boat. This equipment is arranged to enable continuous two-way telephone service between the master of the fire-boat and his land headquarters when the boat is under way. By means of this close communication, it has been possible to coordinate the efforts of the land and marine fire forces more effectively. As a result of the demand for telephone service of this kind in important harbors, both for harbor craft and ocean-going vessels, plans have been made for opening to such service in 1931, radio-telephone stations at Los Angeles, San Francisco, Puget Sound, and New York.

Commercial telephone service between ships at sea and the telephone system of the United States was extended during 1930 so that this service is now available to five ships: the Leviathan, Majestic, Homeric, Olympic, and Belgenland. Several organizations are involved in the provision of this service: the International Marine Radio Company, a subsidiary of the International Telephone and Telegraph Company, the Marconi Company, and the American Telephone and Telegraph Company. The shore stations are operated by the American Telephone and Telegraph Company on this side and by the British Post Office on the European side. During 1930, construction of a new land station at Ocean Gate, New Jersey, to care for transmission from shore to ship was completed. As in all radio-telephone transmitting stations, the antennas at this new station have a marked directional characteristic, the transmitted waves in this case being directed so as to traverse the North Atlantic shipping lanes. Four different wavelengths are used for transmission, ranging between 17.5 and 63 meters. Generally speaking, reliable transmission has been obtainable at distances from New York up to about 1,000 miles, corresponding with two days' sail. While satisfactory talks have been made at distances of 2,500 miles or greater, transmission at such distances has not been uniformly good.

A paper by Messrs. William Wilson and Lloyd Espenschied, discussing radio-telephone service to ships at sea was presented at the Northeastern District Meeting in May 1930.

TELEGRAPHY

During 1930 all Western Union tickers handling New York Stock Exchange service in the United States were converted to the high-speed type. This permitted increasing the output of stock quotations from 300 to 500 characters per minute. In the field of telegraphic distribution of quotations and other market information, many improvements in apparatus and methods of operation were developed and applied during the year which resulted in a reduction of manual handling, greater output and extended operation into territory not heretofore reached, including quotation service to Cuba.

There has been a considerable expansion during the past year in the use of automatic quotation boards for electrically indicating market prices and this service has been extended to a number of other cities in addition to New York, where the first boards were installed.

Numerous additional installations have been made of concentration equipment for printing telegraph circuits. A description of the apparatus used for this purpose is contained in the paper entitled *A Printing Telegraph Concentrator* presented by Mr. W. B. Blanton at the Winter Convention in January 1931.

The Western Union Telegraph Company has developed a method whereby channels of a multiplex system circuit may be automatically repeated and extended individually over single wires by means of simplex printers to offices. Circuits from several offices using simplex printers may be grouped at a central point and combined into a multiplex circuit to a distant central office. This system will give many small offices direct outlets to the large centers which could not have been economically provided with previous methods.

During the year there was a marked increase in the tendency to employ, in place of direct current telegraph to outlying points superposed on telephone circuits, a method of operation which is called "two-path polar operation." This involves the use of independent one-way polar circuits for the two directions and affords improved service with a lower maintenance cost as compared to the usual polar duplex method.

Several methods of measuring the quality of telegraph transmission have been developed. One form of apparatus which has been found very effective both in the laboratory and the field was described by Mr. F. B. Bramhall in a paper entitled *Telegraph Transmission Testing Machine*, presented at the 1931 Winter Convention.

A paper describing various technical features in connection with the submarine high-speed duplex telegraph cable between Bay Roberts, Newfoundland and Horta, Azores was presented at the Winter Convention in 1931 by Messrs. J. W. Milnor and G. A. Randall. At the same convention, Mr. Milnor presented a paper on the influence of interference in submarine cables.

In addition to the statewide police teletypewriter systems in Connecticut and Pennsylvania, an extensive system of about 30 stations was installed last year in New Jersey for the New Jersey State Police. There is an increasing number of large city police networks, such as those of New York City, Boston, Buffalo, and St. Louis. The United States Coast Guard also has such a system in use along the New England Coast.

Progress has been made in the development of switchboards for teletypewriter service to permit the interconnection of these machines in a manner similar to that by which telephone instruments are interconnected.

A new type of belt conveyer has been developed by the Western Union Telegraph Company for carrying telegrams between the various parts of the central office. In this conveyer messages are carried along between a steel channel and a moving flat belt about 1¾ in. wide, the motion of the messages being due to their sliding along the steel channel with practically no friction while adhering quite firmly to the belt. The messages can be taken around vertical or horizontal turns as well as through vertical and horizontal twists.

MUNICIPAL AND PROTECTIVE SIGNALING

There has been a steady increase in the use of electrical traffic signals. In the larger cities there have been several installations of flexible progressive systems, while in smaller places and in outlying sections of the larger cities, the detached intersection type of signal is still largely used. For important intersections and through traffic highways, vehicle controlled signals have been fairly successful but are expensive to install and maintain, as compared with the predetermined period signals. Vehicle control of signals obtained otherwise than by switches imbedded in the street surface, such as light beam control, has been tried out.

There has been a considerable use of electrical caution flashers in place of earlier types employing compressed gas, and practically all new installations are electrical. More illuminated caution signs are being installed and cheaper methods of illumination than by the neon tube method are being investigated

An important development of the past year concerning municipal fire alarms, has been the production of signal boxes and central office control apparatus, making effective use of ground return to send in alarms at such times as the circuit is in abnormal condition. Previous attempts to accomplish this introduced some abnormal condition on an otherwise normal circuit. This defect has now been practically overcome, and signal boxes have been developed that will operate in the usual manner on a normal circuit while at the same time they will transmit signals over a grounded, short-circuited or broken circuit without the necessity of making any temporary alterations at the signal box. While this development is too recent to be able to judge of its effects, it may permit of more leeway in circuit construction than is now considered safe, such as the installation of both sides of a circuit in the same aerial cable. The importance of this improvement may be estimated when it is considered that fires often occur at times when circuit conditions are apt to be disturbed by storm, explosion, or accident.

The use of single battery with trickle charger in place of duplicate batteries charged alternately by motor-generators is increasing with consequent increase in battery life.

The use of rectifiers and floating batteries or of transformers and a-c. circuits in connection with institutional fire alarms has progressed to such an extent that practically all new installations make use of public electric supply for the operating current in preference to primary batteries or to storage batteries charged from motor-generators. The practise of connecting automatic sprinkler alarm valves to municipal fire alarm boxes so that an alarm will be sounded automatically for any appreciable flow of water, has spread.

Experiments have been made on improved flash-light mechanisms for calling patrolmen to signal boxes. One such system has been installed lately in Boston. This permits any citizen desiring to call a policeman to operate an exposed lever which starts the flash-lights blinking the number of the signal box from which the call is made.

TELEVISION

Further advance was made in television as an accessory of telephone conversations by the development of means whereby two people at a distance are enabled both to converse and to see one another as if seated face to face in the same room. One of the interesting problems encountered in this development was that of sufficiently illuminating the faces of the parties engaged so that their images could be transmitted without, at the same time, dazzling their eyes to such an extent that they would be unable to see before them the image of the other party. This difficulty is met by employing blue light for scanning the faces of the parties. While the eyes are relatively insensitive to this color, the photoelectric cells used to pick up the light reflected from the face and generate the television signals are highly sensitive to it. Concealed microphones and loud speakers connected by four-wire telephone circuits are used in place of conventional telephone instruments to provide the talking portion of the system. The problem of operating a loud speaker and a sensitive microphone in the same small booth in such a manner that a self-sustaining singing circuit would not be created has been solved by specially treating the walls of the booth to prevent the reflection of sounds into the transmitter and by so locating both transmitter and loud speaker that the transfer of sound between them is minimized. While the experimental system is only two miles long, the television apparatus will function satisfactorily over distances of hundreds of miles when connected by suitable circuits as was shown by the one-way demonstration between New York and Washington.

Three papers dealing with television, by Messrs. H. E. Ives, F. Gray, M. W. Baldwin, H. M. Stoller, D. G. Blattner, and L. G. Bostwick, were presented at the 1930 Summer Convention. (A. I. E. E. TRANS., Oct. 1930.)

AIRPLANE RADIO-TELEPHONY

Development of telephone communication with airplanes continues to progress, and it has been found to be of very great importance for communication between transport planes and ground stations. Two-way radio-telephone apparatus for communication between planes and ground has been developed and supplied for equipping a comparatively large number of planes. The value of such equipment may be indicated by the fact that legislation provides for increased revenue to air mail contractors flying planes equipped for two-way radio communication

Two papers on this subject were presented during the year, one by Mr. R. H. Freeman at the Pacific Coast Convention, the other by Mr. Eugene Sibley at the Middle Eastern District Meeting in October.

SYNCHRONIZING RADIO BROADCASTING STATIONS

There has been considerable experimental work carried on during the past year by the prominent radio organizations along the line of synchronizing broadcasting stations so that the same radio program may be broadcast from different stations operating at the same frequency. Best results are obtained only with a high degree of synchronism between the carrier frequencies of the different radio stations. In certain of the more successful experiments the control of the radio station frequencies has been carried out by sending over wire circuits standard frequencies of 4,000 or 5,000 cycles which, at the radio stations, are stepped up and used either directly to provide the radio carrier or indirectly to control the frequency of a local oscillator. While it is evident from the tests which were made that line circuits can be used very satisfactorily for transmitting control frequencies, certain requirements are imposed on the radio station frequency step-up equipment to iron out minor line fluctuations, which are, of course, greatly exaggerated when the frequency is raised from the relatively low frequency transmitted over the lines to the radio frequency of from 500 to 1,000 kilocycles.

STANDARDIZATION OF RADIO TERMS

During the past two years the Standardization Committee of the Institute of Radio Engineers has had under way a complete revision of definitions of terms, abbreviations, symbols, and methods of measurements and tests. A preliminary report of this work was issued in December, 1930.

FOREIGN COMMUNICATION MATTERS OF INTEREST

During the year international service was extended in Central America by the interconnection of Guatemala and El Salvador. In Mexico the subscribers of a second large network were given access to the United States and all points reached therefrom.

Conference toll service or multiple telephone service was established in the Netherlands. By means of this system from three to six subscribers in the same or different cities may be interconnected at the same time so that any one of the subscribers may be heard by all of the others.

Picture transmission service was extended in a number of countries, particularly in Japan.

In Europe the toll cable network was increased during the year by 6,000 to 8,000 kilometers. Two additional submarine cables were placed across the English Channel and one was placed between Sweden and Germany.

A complete rotary automatic exchange system was installed in Vatican City and connections were established with the international network.

Direct dialing over long distance telephone lines was successfully demonstrated in Europe and installations were made in several countries. Toll dialing has been employed in the United States to a limited extent for a number of years.

Transatlantic radio-telephone service was extended to include a number of new countries in Europe and to reach additional points in countries to which service had previously been given. Connections to points within the Antarctic Circle became possible for the first time when the service was extended in South America to include a number of additional cities in Argentina and Chile.

During the year the International Telephone and Telegraph Corporation, in cooperation with the government administrations concerned, opened direct radio-telephone links connecting Buenos Aires with Paris, Berlin, and London. These additional links between South America and Europe not only decrease the use of long land lines formerly required to serve points distant from the radio terminal, but greatly increase the reliability of the international connections as a whole. When, because of atmospheric disturbances or for other reasons, one link is unable to give commercial service, the traffic may be routed over one of the other links. The question of allotting the traffic over the different circuits and adjusting rates so that the rate between two points will not depend upon the routing of the call has been by no means a simple one, but with the cooperation of the various government administrations much progress has been made.

Commercial service was made available between telephone subscribers in Chile, Uruguay, and Argentina, and subscribers in Belgium, Denmark, Switzerland, Austria, Lithuania, Poland, Esthonia, Norway, Sweden, Czechoslovakia, and Jugoslavia through one or another of the four direct links from Buenos Aires which, of course, also serve Spain, France, Germany, and Great Britain.

Commercial telephone service was opened to some of the Canadian National Railway express trains and equipment for the reception of broadcast programs on moving trains was provided in a number of countries, including Jugoslavia, Italy, and Austria.

During the year technical development work continued to prepare for improvements in existing apparatus and methods as well as to explore new fields, such as signaling and dialing over radio-telephone circuits, and the use of the so-called ultra short waves, those of under five meters.

COOPERATION BETWEEN WIRE USING COMPANIES

The many problems arising in coordinating the wire plants of the power and telephone companies led to the formation of the Joint General Committee of the National Electric Light Association and Bell Telephone System in 1921. Since that time an extensive program of investigation has been in progress and many important results of this work were published in 1930 as Volume 1 of Engineering Reports of the Joint Subcommittee on Development and Research. A review of the work of this subcommittee was given in a group of four papers presented at the 1931 Winter Convention as a symposium on the coordination of power and telephone plants.

During the last two or three years three other Joint General Committees have been organized with the general objective of working out methods of procedure for the coordination of wire plants. These are the Joint General Committee of the Western Union Telegraph Company and the National Electrical Light Association, the Joint General Committee of the American Railway Association and National Electric Light Association and the Joint General Committee of the American Railway Association and the Bell Telephone System. These committees are proceeding with the formation of the fundamental bases of procedure for the cooperative handling of mutual problems between the utilities concerned and the carrying out of such development and research work as appears to be necessary in connection with the problems involved.

APPLICATIONS OF PROBABILITY THEORY IN TELEPHONE PRACTISE

The importance of the probability theory and the related theory of statistics in telephone practise are, in a general way, well known by the engineering profession. However, a short résumé of the matter together with a brief statement of additional applications made during the last year may be welcome.

The oldest and best known application of the theory in the art of communication is its use in the determination of the loads which can be placed on various manual and dial trunking arrangements in order that efficient service be rendered. Unbalance effects on loaded circuits and other transmission lines of periodic structure also give rise to linear and other types of error function problems for the solution of which recourse to probability theory must be had.

The scheduling of adequate sampling plans for determining the quality of telephone equipment at various stages of its manufacture, after delivery to the operating companies and after installation, make heavy demands on probability and statistical theory. Within the last year extensive sampling schedules have been made for determining the extent to which the human factor in the telephone business is performing its assigned functions. For example, sampling theory is now being applied with reference to the performance of the repair clerk and test desk man, the quality of work done by installers and repairmen, the quality of subscribers' contacts in commercial offices and the quality of directory printing and delivery service.

Electric Welding

ANNUAL REPORT OF THE COMMITTEE ON ELECTRIC WELDING*

THIS report consists of two sections; the first dealing with the Organization and Policies, and the second with the Progress of the Art.

I. ORGANIZATION AND POLICIES

During its first three years, this newly created committee has gradually extended its field of action until the field overlapped that of various technical committees of the American Welding Society. It was necessary, therefore, to establish a clear understanding with the A. W. S. in order to create an exchange of information and to avoid duplication of effort. It became apparent that it would be more profitable to leave such problems as the metallurgy of the welding processes, methods of testing the completed welds and organization of the procedure control, to the committees of the A. W. S.

Our efforts have been concentrated, therefore, on sponsoring the advancement of the theory of the electric arc, the design of the electric welding apparatus and the use of electric welding processes in the manufacture of electrical machinery.

The gathering of all available information on the progress of the art and the presentation of these facts through the medium of our annual report to the whole membership of the Institute is another important function of this committee.

As the activities of our committee have increased, it was felt at the beginning of the present fiscal year that the time had come to organize several subcommittees composed of physicists and engineers especially interested in one of the above specific problems. The committee as a whole has been concerned with the general survey of the advance in the progress of the art.

The present organization of subcommittees is as follows:

Research (Phenomenon of the Electric Arc) Dr. S. Dushman, Chairman, Dr. J. Slepian, Mr. H. M. Hobart, Mr. W. Spraragen, Mr. A. M. Candy.

Electric Welding Machinery (Designs of) Prof. F. Creedy, Chairman, Mr. J. C. Lincoln, Mr. A. M. Candy, Mr. A. Churchward, Mr. H. M. Hobart, Mr. K. L. Hansen.

Resistance Welding. The subcommittee on Resistance Welding has only been partly organized with Mr. E. Lunn and Mr. H. W. Tobey gathering preliminary information.

Papers

Through the efforts of the members of our committee, a symposium on welding was presented during the Winter Convention of the Institute. A paper by Dr. G. M. Shrum and Mr. H. G. Wiest, Jr. was presented by Dr. S. Dushman which related to the new experiments of the phenomenon of the electric arc.

Three papers were presented by Mr. J. H. Blankenbuehler, Mr. S. R. Bergman and Professor F. Creedy on the subject of the design of electric welding generators.

Two papers by Mr. M. Thomson and Mr. S. Martin, Jr. were on the subject of the resistance welding as applied in the manufacture of electrical apparatus.

Another paper on the design of the electric welding generator was published in the JOURNAL of the A. I. E. E. prior to the above Convention, by Mr. C. J. Holslag.

II. PROGRESS OF THE ART

General

The past year was characterized, first, by an outstanding improvement in the quality of the welds produced by various methods, secondly, by the refinement in the design of electric welding equipment, and thirdly, by the unprecedented expansion in the use of the resistance welding process.

The methods of testing and the procedure control attained such refinements that the quality of the welds produced on pressure vessels can be checked with accuracy.

The most outstanding accomplishment in the field of application of the electric arc in the past year, is the fabrication of 24 all-welded steam boilers by the Babcock & Wilcox Company for the United States Navy for installation on the new scout cruisers.

In the past, the arc welded oil stills for high pressure were manufactured successfully for a number of years by the A. O. Smith Corp., yet it is the first time that high-pressure steam boilers were fabricated by the electric arc and installed on the fighting ships.

Improvement in the Quality of Arc Welds

Arc welding was introduced into general use in this country during the World war. The first attempts to adopt the European method of welding with heavily fluxed electrodes, did not meet with general approval. Instead, the technique of welding with bare wire electrodes was developed to such an extent that practically all the arc welding in this country was done, until recently, by that method.

---

*COMMITTEE ON ELECTRIC WELDING:

P. P. Alexander, Chairman,
C. A. Adams,
A. M. Candy,
Alexander Churchward,
F. Creedy,
S. Dushman,
F. M. Farmer,
K. L. Hansen,
H. M. Hobart,
C. J. Holslag,
J. E. Kearns,
J. C. Lincoln,
Ernest Lunn,
B. T. Mottinger,
J. W. Owens,
J. Slepian,
William Spraragen,
H. W. Tobey.

Since the tensile strength of the welds produced with such electrodes is about the same as that made by the most expensive heavily fluxed electrodes of European make, for many applications the bare wire is entirely satisfactory. It should be noted, however, that both bare wire electrodes and heavily fluxed electrodes of European make produced welds lacking in ductility.

With the extension of the field of application of arc welding, it soon became apparent that for the use of arc welding on such structures as pressure vessels, electrodes of different types would be needed. Over ten years ago, work in this direction was started by the Electric Arc Cutting & Welding Co., Wilson Welder & Metals Co., and some other concerns and individual investigators, each of whom produced a new type of heavy or lightly covered electrode. These electrodes had certain advantages over the bare wire electrodes.

Decided advance in the improvement of the quality of the welds was made a few years ago by the General Electric Co. with the hydrogen gas shielding of the weld, by A. O. Smith Corp. with special wood pulp covered electrodes, and by several other individual investigators and concerns, each of whom developed in the last year or two, a very efficient type of fluxed electrode giving welds of high ductility, a quality which is absolutely essential for work on steam boilers and many other types of pressure vessels.

At the present time, several manufacturers of pressure vessels, in advertising their welds guarantee a ductility unheard of only a few years ago. The General Electric Co., A. O. Smith Corp., Blaw-Knox Co., Struthers-Wells Co., Kellog Company, Fusion Welding Corp., The Lincoln Electric Co., and Babcock & Wilcox Co. are probably only a part of the list of concerns now producing highly ductile welds. This advance in the quality of the produced welds opened new fields for arc welding, of which the steam boilers for the United States Navy is an outstanding example.

Resistance Welding

The welds produced by this process are of the highest quality with respect to strength, ductility and resistance to fatigue. The development, therefore, consisted mostly in the improvements in the design of the welding machines and application of such machines in new fields.

The most outstanding feature of the past year was the great development of welding pipes by the resistance process. Several machines up to 6,500 kva. each have been built for welding, by the flash welded process, longitudinal seams 40 ft. long. By the use of such machines, a weld 40 ft. long is produced simultaneously all along the seam and in less than one minute on pipe some 24 inches in diameter and of a plate up to ½ inch in thickness. Similar resistance welding machines of 1,200-kva. capacity weld circumferential seams of similar pipe. All the electrical parts for the above machines have been built by the Swift Electric Welder Company. A spot welder of 800 kva. with electrodes of 3½ inches in diameter, which probably is the largest machine ever built in this country, has been successfully built by the same Company for special heavy welding work.

Other concerns (amongst which the Thomson-Gibb Electric Welding Co. is the pioneer), developed the continuous method of seam welding. This last method had previously been used on a large scale for welding thin walled tubing. Within the last year, this method has been applied to the continuous seam welding of pipe of considerable diameter and wall thickness. At the present time, several manufacturing concerns are producing welded pipe up to 40 ft. long and it is expected that by butt welding two of such lengths in the factory, a pipe of 80 ft. long will be available for construction work.

This great development in the welding of industrial pipe by the resistance process was due to the decision of several large concerns to extend the pipe lines for transportation of natural gas and gasoline from the producing areas to the consuming districts over 1,000 miles away.

This development should be of especial interest to engineers since it indicates the possibility of transmission of power over longer distances by gas than have been accomplished by the electric current.

As was remarked by a well-known consulting engineer, the electrical engineer should rise to the occasion and surpass gas with respect to distance and amount of power transmitted. He has plenty of as yet undeveloped alternatives to the 60-cycle synchronous system as at present employed.

The resistance welding process is being further developed in the application to the automobile industry where it greatly outdistances all the other welding processes. Another important field of application of resistance welding is the manufacture of wire goods which comprises even such fields as the welding of wire netting for reinforced concrete. Machines making up to 24 welds simultaneously have been built and are in successful use. In the fabrication of electrical machinery, the resistance process has already been applied on a large scale to the manufacture of small transformer tanks. The application of this process has also extended to the fabrication of motor magnet frames.

Structural Steel Welding

In the field of structural steel, arc welding has already proved to be entirely satisfactory, and therefore, received further important applications. All arc welding of this type of construction is done with entire satisfaction with the bare wire electrodes.

Amongst the high buildings erected during the past year, (partly by welding and partly by riveting) are the buildings of the Southern California Edison Co., the Edison Electric & Illuminating Co. of Boston, and the DuPont Corporation at Wilmington, Delaware. The highest building entire'y welded was erected by the Dallas Power & Light Co. This building has 19 stories and measures 246 feet above the foundations. The Westinghouse company erected several industrial and office buildings, all entirely welded. The highest of these buildings measures 190 feet above the foundations. It should be noted that in the erection of the buildings, only very few welding machines are necessary. In the erection of the 19 story building at Dallas, only four arc welding machines were used.

Shipbuilding

In the shipbuilding field, arc welding is being extended rapidly and all our shipbuilding companies such as the Newport News Shipbuilding & Drydock Co., The Bethlehem Shipbuilding Co., and many others as well as the U. S. Navy Yards, are using arc welding quite extensively for fabricating various internal structures on ships. On smaller ships, the electric arc has been used successfully even in welding the hulls.

The Electric Boat Company, at Croton, launched during the past year, an all welded barge, 118 ft. long, of Ewertz patented design. The Federal Shipbuilding & Drydock Co., at Curney, N. J., welded a number of barges, and the Standard Steel Shipbuilding Corp., of Los Angeles, completed an all-welded 65-ft. yacht.

The application of arc welding in shipbuilding requires a careful study of the design of the welds and the details of the technique of welding. The long welded seams characteristic in this type of construction may be subject to high internal stresses and therefore should be produced by the best known methods and electrodes. The amount of welding per ton of steel in shipbuilding is very much greater than in the erection of buildings where only the short welds are necessary. It may be expected that in the construction of barges and small vessels for internal navigation, arc welding will soon outdistance riveting.

Automatic Machines, Alloy Electrodes and Special Arc Torches

The design of automatic arc welding machines advanced still further and several concerns are now manufacturing either full automatic or semi-automatic machines of a very efficient design for use with metallic electrodes. The Lincoln Company made further improvements in automatic carbon arc welding machines which produce welds of high ductility, and the General Electric Company applied the atomic hydrogen process to automatic welding as well as for hand welding.

The development of special alloy electrodes for hand welding as illustrated by the Stoody process, made considerable progress. The surfacing of various parts of machines subject to wear and abrasion with hard surfaces in certain cases can be successfully accomplished.

The development of special torches for use of indirect arc (similar to the flaming arc) extended the field of arc welding to the low-melting-point alloys. A special torch developed by Hansen and utilizing the d-c. arc can now be used for brazing, soldering, and welding low-melting-point extruded alloys. Another torch utilizing the a-c. arc has also been put on the market by the Warner Co., of Los Angeles. It can be used successfully on light work of brazing, soldering, and welding steel sheets of light gage.

Design of Electric Arc Welding Generators

The advances and refinements in the design of the electric welding generators have been carefully followed by the subcommittee on Electric Welding Machinery, which reports as follows:

An outstanding feature of the year's work in the development of direct-current arc welding generators, is the attention which has been devoted to their transient characteristics. It has been realized that the momentary shortening of the arc produces a large momentary transient current, which tends to cause explosions or "sputterings" detrimental to welding. Means have, therefore, been sought by several workers by which these momentary transient currents may be eliminated and papers on the subject have been presented by Blankenbuehler, Bergman, Holslag and Creedy.

The direct-current welding generators contain a main exciting coil either shunt, separately excited, or a combination of the two, and a demagnetizing series circuit whose function is to reduce the voltage with increasing current. One important type of transient is caused by the voltage induced in the main exciting circuit by transformer action from the series demagnetizing circuit and this type of transient may be eliminated by reducing this voltage to a small value. There is no need to eliminate this voltage altogether because it is only necessary to reduce it to such a degree that the solutions of the differential equations which determine the current approximate to the logarithmic instead of the oscillatory type. Blankenbuehler discussed a machine with separately exciting coil and reverse series winding only, and injects into the separately excited circuit a voltage proportional to the current flowing through the reverse series winding (the welding current) by means of a series transformer. This voltage is opposite in direction to that induced in the same coil by the reverse series winding so that the two tend to cancel.

The machine treated by Bergman has two distinct poles whose flux cuts the conductors between positive and negative brushes. One has constant flux and the other is shunt excited from a third brush intermediate between the main brushes, armature reaction being relied upon to reduce its voltage with increasing current. In this case a series transformer is used to inject into this shunt circuit a voltage proportional to, but opposite in direction to that due to induction from the armature.

In Creedy's machine in which the effect of shunt and separately excited windings is produced by a single coil, no transformer is employed but the same result is produced by reducing the reluctance of the main magnetic circuit so that the number of turns on the main exciting coil is very much reduced and consequently the e. m. f. induced in it by the series demagnetizing circuit becomes small. With this latter device a neutralizing winding becomes necessary to avoid sparking and excessive reactance of the armature winding.

Testing of Welds

Several non-destructive methods of testing of welds have been developed among which the X-ray method is already being applied as a regular procedure control on welds made on important structures. The magnetic and the stethoscope methods are also available. It should be noted also that a series of experiments has been conducted with the gamma rays produced by radium emanation for testing of welds on heavy plates and steel castings.

Further Research

Since the electric arc is the foundation on which the entire arc welding industry has been built, our subcommittee on Research recommends further study of this phenomenon. The outlined problems are as follows:

1. Probe measurements in arcs between iron electrodes, using a technique somewhat similar to that adopted by Nottingham in his investigations on the arc between copper electrodes in air.
2. Arc characteristics should be taken as a function of the pressure for different gases, such as carbon dioxide, air, and argon.
3. The question of the part played by fluxes, or additions of various "dopes" to the welding rod.
4. Determinations of the energy consumption at the electrodes, using a calorimetric method.
5. Accurate determination of cathode drop and its variations under varying conditions. This is an important factor in all theories of the electric arc and more accurate information on this point is certainly desirable.
6. Accurate determination of anode drop under varying conditions.
7. Study of small current arcs and particularly the glow to arc transition.
8. Mathematical study of some of the newer ideas on stability of discharges as developed by Barkhausen and others.
9. Cathode-ray study of stability of arcs such as used in electric welding. The spontaneous variations in current and voltage which are always taking place will probably be frequently beyond the capacity of the ordinary oscillograph. The influence of high frequency characteristics of the external circuit could be studied in this connection.
10. Stability of arc in magnetic field. Since arcs used in welding usually have quite strong magnetic fields, the influence of this factor in the stability of an arc is quite important.
11. Study of influence of nature of cathode surface on stability.
12. Study of influence of nature of anode surface on stability.
13. Study of passage of the deposited metal from the electrode to the work. Although a large part of the metal is deposited by liquid drops, it may be that a considerable portion passes in the form of vapor.
14. Study of the influence of superimposed alternating current of moderate and high frequency. The use of high frequency has been proposed for actual welding, but the influence upon the arc has not been studied in much detail.

It has also been suggested that the carbon welding arc be further studied, especially with respect to the blast of carbon vapor from the cathode spot.

University Activities

Through the initiative of the American Bureau of Welding, twelve engineering colleges and universities have become interested in various problems relating to welding. In addition to the research work conducted by professors, the students in several colleges write their theses on welding in preparation for the degree of B. S. or M. S.

It should be noted that welding, and especially electric welding, is receiving considerable attention in various universities abroad. Germany is probably leading in that respect because electric welding is considered to be of such importance that some colleges in that country confer the degree of Doctor of Engineering for any adequate research work on problems of welding.

In the Soviet Union, welding has received during the past year, an unprecedented expansion. To deal more adequately with the problem of a highly trained personnel, a special Welding Institute is being organized which will cost over $1,500,000, to train future welding engineers.

Electrical Machinery

ANNUAL REPORT OF COMMITTEE ON ELECTRICAL MACHINERY*

I. Organization and Activities

THE committee is organized with five permanent subcommittees, and its work has consisted of the review of papers, arrangement of programs for technical sessions, and the preparation of Standards and Test Codes.

Forty papers on electrical machinery were presented during the calendar year 1930. Others could have been made available if facilities for presentation and publication had permitted. The committee believes that the preparation of short and informal papers designed to bring out discussion at conventions should be encouraged, and that highly technical papers whose chief value is for reference should be presented before small groups in parallel sessions.

Standards

The Subcommittee on Transformers has been very active and during 1930 prepared "Recommendations for the Operation of Transformers" and brought to conclusion a revision of the A. I. E. E. Standards for Transformers.

The Subcommittee on Synchronous Machines, besides completing A. I. E. E. Standards for Capacitors, has initiated a number of revisions for the A. I. E. E. Standards for Synchronous Machines.

The Subcommittee on Mercury-Arc Rectifiers is working in close cooperation with the Sectional Committee on Rectifiers, which has under preparation Standards for Mercury-Arc Rectifiers.

Test Codes

Preliminary drafts of test codes for transformers, induction motors, direct-current machines and synchronous machines have been prepared. These codes are intended to provide definite instructions for the more generally applicable field and factory methods of conducting and reporting acceptance and other tests of general commercial value.

II. Resumé of Progress of the Art

SYNCHRONOUS MACHINES

Steam-Turbine Driven Alternators

The size of the single-shaft units has again been increased, two 200,000-kva., 0.8 power-factor, 1,800-r. p. m., single-shaft, tandem-compound, turbine-generator units (GE)† now being built for the Hudson Avenue Station of the Brooklyn Edison Company. They have double windings rated at 16.5 kv., and double-winding auto-transformers will step up the voltage to 27.6 kv.

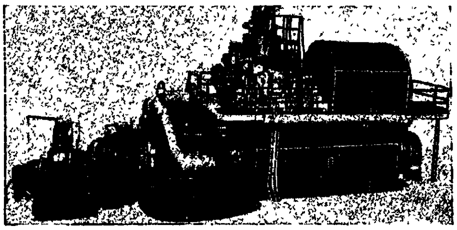


FIG. 1—50,000-KW., 3,600/1,800-REV. PER MIN., VERTICAL-COMPOUND, TURBINE-GENERATOR UNIT (GE)—PACIFIC GAS & ELECTRIC CO.

A 110,000-kw., 1,200-lb., vertical-compound, double-winding turbine-generator unit (GE), with duplicate generators on the high- and low-pressure turbines, has been constructed for the Ford Motor Company.

A 50,000-kw., 3,600/1,800-r. p. m., 1,200-lb. unit, in which the high- and low-pressure elements were combined to form a vertical-compound turbine-generator set (GE) was constructed for the Pacific Gas & Electric Company and a duplicate unit is nearing completion. (Fig. 1.)

Three 18,750 kva., 3,600-r. p. m., turbine-generator units (W), the largest machines of this speed yet manufactured in this country, were put in operation at Baton Rouge by the Louisiana Steam Products Company. An outstanding feature of these machines is the internal propeller fan used, the success of which has created a new interest in internal fans for large machines.

High-voltage turbine generators rated 121,000 kva., 18 kv.; 147,000 kva., 22 kv.; and 94,000 kva., 22 kv. are now in the first stages of construction (AC).

The satisfactory completion of tests on a 9,375 kva.

---

†Legend for Manufacturer Designation:

In order to conserve space and avoid numerous repetitions of the names of manufacturers, the following designation has been used throughout the report:

AC—Allis-Chalmers Manufacturing Co.
BB—American Brown Boveri Co.
CGE—Canadian General Electric Company
CW—Canadian Westinghouse Co., Ltd.
EM—Electric Machinery Mfg. Co.
GE—General Electric Co.
W—Westinghouse Electric & Mfg. Co.

*COMMITTEE ON ELECTRICAL MACHINERY:

P. L. Alger, Chairman,
L. F. Adams,
B. L. Barns,
W. M. Dann,
H. B. Dwight,
C. M. Gilt,
T. T. Hambleton,
A. L. Harding,
C.F. Harding,
S. L. Henderson,
L. F. Hickernell,
J. A. Johnson,
H. C. Louis,
A. M. MacCutcheon,
O. K. Marti,
V. M. Montsinger,
E. L. Moreland,
F. D. Newbury,
R. W. Owens,
E. B. Paxton,
A. M. Rossman,
R. B. Williamson,
H. L. Zabriskie.

hydrogen cooled, turbine generator (W) (Fig. 2) have encouraged the serious consideration of hydrogen cooled turbine generators for ratings above 30,000 kva.

Waterwheel-Driven Alternators

The year 1930 has been notable for the number of large hydro-electric developments which have either been contemplated or put into operation. Table I is a list of some of the more interesting hydraulic-driven generators installed or under construction during the past year.

The 77,500-kva. generators (GE) for the Dnieper River Development in Russia, operating under a hydraulic head of 123 feet are the largest waterwheel generators yet constructed. (Fig. 5.) The total weight of each generator will be approximately 880 tons, the weight of the rotor and shaft will approach 445 tons, and the shaft itself, which is 36 ft. long and 40 in. in diameter, with a 70-in. flange on each end, will weigh about 68 tons. The stator is fabricated in six sections with punchings and windings assembled in each section before shipment.

TABLE I—WATERWHEEL-DRIVEN ALTERNATORS

Purchaser—Location	No.	Kva.	R. p. m.	Type	Fig.	Mfr.
Amtorg Trading Co	4*	77,500	88.25	Vert	4	GE
Dnieper River (Russia)	1	77,500	88.25	Vert		GE
City of Seattle Skagit River	2	66,700	171.5	Umbrella		W
Inland Power & Light Co Ariel Development	1	56,250	120	Overhung		GE
Alcoa Power Co Chute-à-Caron	4	50,000	120	Vert		CW
New York Power & Light Corp Spier Falls	1*	47,000	81.8	Overhung		GE
Beauharnois Power & Light Co. St. Lawrence River	2	46,625	75	Umbrella		CGE
St. Lawrence River	2	43,883	75	Umbrella		CGE
Western Power Co. of Can. Ltd Ruskin Generating Station B. C.	1	44,000	120	Umbrella		CW
Lexington Water Power Co. Saluda Development	4*	40,625	138.5	Umbrella	3	W
New England Power Construction Co. Fifteen Mile Falls	4*	39,000	138.5	Umbrella		W
Shawinigan Engineering Co Rapid Blanc Development	4	36,000	109.1	Vert		CW
Pennsylvania Water & Power Co. Safe Harbor, Susquehanna River	4	31,111	109	Overhung		GE
	2	31,111	109	Umbrella		W
New Kanawha Power Co. New Kanawha River	4	30,000	150	Vert		W
Pacific Gas & Electric Co. Tiger Creek	2	30,000	225	Horiz		W
Gatineau Power Co Paugan Falls P. Q.	1	28,500	125	Vert		CW
James MacLaren Co Masson Power Development	4	28,000	166.7	Vert		CW
Shawinigan Water & Power Co Grand Mere, P. Q.	1	25,000	112.5	Vert		CW
Toccoa Electric Power Co. Blue Ridge	1	25,000	164	Umbrella		W
Montana Power Co. Morony	2*	25,000	81.8	Umbrella		W
Hydro Electrica Espanola Spain	2	25,000	375	Vert		GE
Union Electric Lt. & Pr. Co Osage River	6	23,888	112.5	Umbrella		W
Chats Falls Executive Board	8	23,500	125	Vert		CW
San Joaquin Light & Power C . Merced Falls	1	4,000	128	Vert	4	W

*Included in report of last year.

The 31,111-kva., 109-r. p. m., umbrella-type generators (GE and W) for the Safe Harbor Development of the Pennsylvania Water & Power Company are to be driven by Kaplan-type turbines, and will operate as motors in a reversed direction to pump water back into the fore-bay for use during the peak-load periods.

High Frequency Generator

A 500-kva., 960-cycle generator (W) built for the American Brass Company will supply power for an electric furnace. The rotor required special construction to retain the field coils in place at the high peripheral speed of 20,000 ft. per minute.

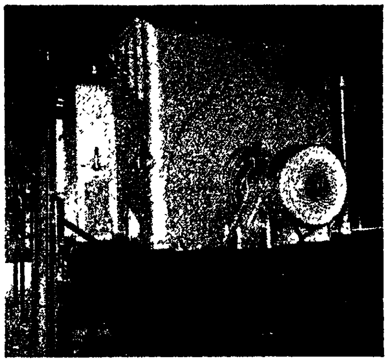


Fig. 2—9,375 Kva., Hydrogen-Cooled, Turbine-Generator (W)

A 666-kva., 960-cycle single-phase generator (GE) was placed in operation at Watertown (Mass.) Arsenal in November, 1930, and a 750-kva., 960-cycle, three-phase generator (GE) is being built for the American Brass Company.

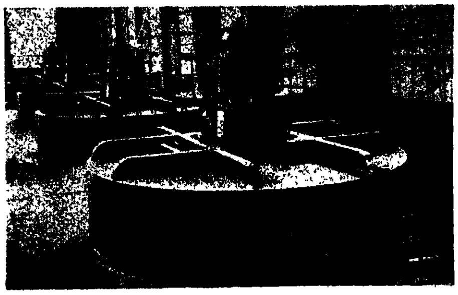


Fig. 3—Four 40,625-Kva., 138.5-Rev. per Min., Umbrella-Type, Waterwheel-Generator Units (W)—Saluda Development, Lexington Water Power Co.

Synchronous Condensers

A 50,000-kva., 13.2-kv., 600-r. p. m., 50-cycle hydrogen-cooled condenser (GE), equal in capacity to the largest air-cooled machines, has been constructed for the Southern California Edison Company. (Fig. 6.) The total capacity of hydrogen-cooled condensers now in service is 137,500 kva. with 70,000 kva. additional on order.

Two 15,000-kva., outdoor hydrogen-cooled condensers (W) have been constructed; one rated at 50 cycles, 750 r. p. m. for the Southern California Edison Company, and the other rated at 60 cycles, 720 r. p. m. for the Indiana & Michigan Electric Company.

A 7,500-kva., 6.6-kv., 900-r. p. m., 60-cycle air-cooled, outdoor condenser (AC) has been constructed for the Central Illinois Public Service Company. (Fig. 7.)

Industrial Synchronous Motors

The application of synchronous motors to industrial purposes is being extended as the knowledge of the starting, acceleration, and pull-in requirements is increased and as the prediction of these characteristics becomes more exact. A number of unique designs has been developed during the year.

A 500-hp., 72-r. p. m., vertical-shaft motor (GE) has been applied to a Fuller Lehigh coal pulverizer, in which the motor frame forms the base on which the pulverizer is built. The motor develops considerably more than normal torque from start to pull-in in order to obtain successful starting with a choked mill. Overvoltage for starting is supplied by a step-up autotransformer.

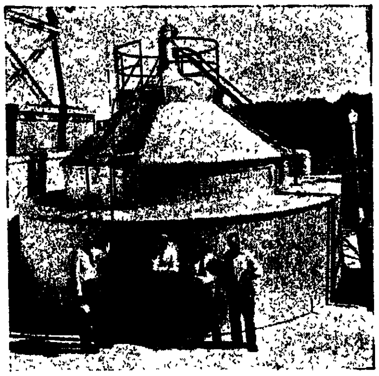


Fig. 4—4,000-Kva., 128-Rev. per Min., Vertical-Type, Outdoor, Waterwheel Generator (W)—Merced Falls, San Joaquin Light & Power Co.

A 700/350-hp., 2.3-kv., 277/138-r. p. m., three-phase, 60-cycle, two-speed synchronous motor (W) has been applied to a vertical centrifugal pump for the Ford Motor Company.

A new method for securing reduced starting kva. has been introduced, which utilizes the inherent reactance of the motor itself, a 3,000-hp. (GE), five 3,500-hp. (EM) and several smaller motors having been built. The stator is wound with two or more parallel circuits so arranged within the core as to obtain increased reactance when only one of the circuits is energized. The starting characteristics obtained are somewhat similar to those secured by using external reactors in series with the lines.

A 600-hp., 440-volt, 300-r. p. m., three-phase, 60-cycle, synchronous motor (EM) was applied for the first time for continuous reversing duty on a copper rolling mill, synchronous motors having been generally considered unsuitable for constant reversing duty on account of their inferior starting characteristics. The operating requirement that the mill be reversed from full speed forward to full speed reverse in five seconds necessitated special design of the stator and rotor to dissipate heating, which was accomplished by the use of ventilating spacers in the armature core and field poles and by special cage end-ring construction. (Fig. 8.) Three parallel circuits were used in the stator, which were switched successively both for forward and reverse acceleration in order to reduce the increment starting kva. demand.

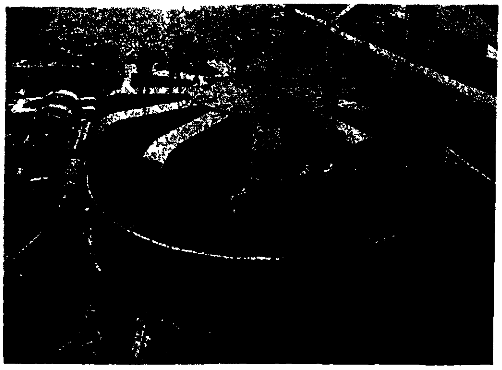


FIG. 5—77,500-KVA., 88.25-REV. PER MIN.. VERTICAL-TYPE, WATERWHEEL GENERATOR (GE)—DNIEPER RIVER DEVELOPMENT (RUSSIA) AMTORG TRADING COMPANY

A slow-speed, vertical-shaft motor (EM) has been incorporated in a pulp hydrator base. The motor was provided with a thrust bearing which carries the weight of the rotor and hydrator rotating member. To permit adjustment of the clearance between the rotating and stationary members of the hydrator, the motor was provided with a micrometer raising and lowering device, the field poles being slightly longer than normal to permit a moderate movement of the rotor axially with respect to the stator.

FIG. 6—50,000-KVA., 13.2-KV., 600-REV. PER MIN. 50-CYCLE, HYDROGEN-COOLED SYNCHRONOUS CONDENSER (GE)—SOUTHERN CALIFORNIA EDISON CO.

Marine Synchronous Motors

Several electric-propelled vessels of interesting design were placed in service or are under consideration.

TABLE II—MARINE SYNCHRONOUS MOTORS

Vessel (or purchaser)	No.	Hp.	R. p. m.	Mfr.
S. S. Santa Clara	†2	6,300	120	GE
S. S. Morro Castle	†2	8,000	143	GE
S. S. Oriente	†2	8,000	143	GE
S. S. President Hoover*	†2	13,250	133	GE
S. S. President Coolidge	†2	13,250	133	W
United Mail S. S. Company (6 vessels)‡	12	5,500	125	GE

*Launched December 1930, Transoceanic service 1931.
†Included in report of last year.
‡Under construction.

The 13,250-hp., 133-r. p. m. ship-propulsion motors (GE, W) are the largest marine synchronous motors yet built. These motors are completely fabricated.

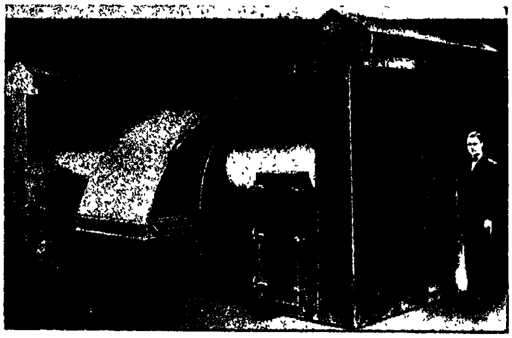


FIG. 7—7,500-KVA., 6.6-KV., 900-REV. PER MIN. 60-CYCLE, AIR-COOLED, OUTDOOR, SYNCHRONOUS CONDENSER (AC)—CENTRAL ILLINOIS LIGHT CO.

Frequency Converters

There is a growing tendency to install large machines outdoors in order to reduce building costs. The first frequency-converter units to be so installed have been built during 1930 and will be placed in operation during 1931.

Two such units, the generators being rated at 21,000 kva., 0.7 power factor, 300 r. p. m., 25 cycle, one-phase, and the motors at 18,000 kva., 0.9 power factor, 300 r. p. m., 60 cycle, three-phase (W) will be installed at the Wayne Junction Substation of the Philadelphia Electric Company to supply power for the new Reading Railroad Electrification (Fig. 9). Conventional indoor design was followed, with spring mountings to absorb the single-phase torque pulsations, the machine being adapted for outdoor service by enclosing in a sectionalized sheet steel housing approximately 64 ft. long by 25 ft. wide.

INDUCTION MACHINES

A major activity of the manufacturers during the year has been the development of new lines of induction motors to conform with the frame sizes and mounting dimensions standardized by the National Electrical Manufacturers Association as announced in last year's report. In many cases this program has included a change in electrical design to improve the noise and torque characteristics. Much attention has also been given to the appearance in order to meet the ever more exacting aesthetic tastes of the public.

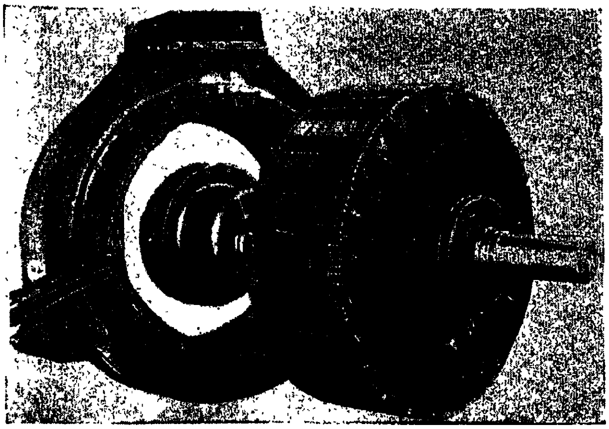


FIG. 8—600-HP., 440-VOLT, 300-REV. PER MIN. 60-CYCLE, CONTINUOUS-REVERSING-DUTY, SYNCHRONOUS MOTOR (EM)—COPPER ROLLING MILL

Several manufacturers now furnish lines of motors in integral up to 100 hp. as well as fractional horsepower sizes for class I and class II hazardous locations (inflammable gases and combustible dust) as defined in the National Electrical Code.

Complete lines of totally-enclosed, fan-cooled continuous duty 55-deg. cent. motors as large as 250 hp., particularly suited for use in harmful dust conditions, have now been developed by many manufacturers and the use of this type is steadily growing.

An extensive application of a novel induction motor (GE) has been made to conveyor tables in steel mills. (Fig. 10.) The conveyor roller is a hollow cylinder mounted on ball or roller bearings rotating around a stationary supporting shaft on which the stator is mounted. The cylindrical convey roll, which surrounds the stator, serves as a secondary, the induced currents flowing in the solid steel inner surface of the roll.

D-C. MACHINES

Motors and Generators

An 8,000-hp., 800-volt, 40- to 100-r. p. m., motor, having a peak capacity of 22,000-hp., 2,900,000-lb. ft. torque, has been built (GE) for a blooming mill of the Illinois Steel Company. This is the largest single-armature motor employing fabricated construction for the major parts.

Two 5,000-hp., 40-r. p. m., double-armature motors were built (W) for operating the main rolls of the new 10,000-hp. blooming mills at the South Chicago Plant of the U. S. Steel Corporation, which is the most powerful mill yet built. Each of the two main rolls is driven by one of the motors, the two being kept at the same speed by electrical control instead of being geared together as in former installations. Each double motor has a peak-torque capacity of two million lb. ft. Power is supplied from three 3,000-kw. induction motor-generator sets. The series fields of the three generators are interconnected in such a way that parallel operation is secured with satisfactory division of load.

Planer motors up to 75 hp. rating with speed ranges by field control of 6 to 1 have been developed (GE and W), and further increases in size of this class of motor are under consideration.

A 50-hp., 1,600-r. p. m., 75-deg. cent. one-hour motor has been developed (W) for application on a coal cutter to meet a limiting over-all height of 12 in.

Six 3,500-hp., 330-r. p. m,, motors have been constructed (AC) for a 96-in. plate mill of the Illinois Steel Company. Power is supplied by two 6,000-kw. synchronous motor-generator sets.

Two motor-generator sets, consisting of two 3,000-kw., 600-volt, compensated generators driven by one 6,500-kva. synchronous motor, have been constructed (GE). These sets will deliver 6,000 kw. continuously with 9,000 kw. for two hours or 7,500 kw. continuously without overload.

Exciters

Further developments in "rapid response" exciters have occurred during the year, with the objects of securing higher efficiency and improved control. Th use of a special Wheatstone Bridge type of rheostat (GE) enables the exciter to operate down to zero or even reversed voltage.

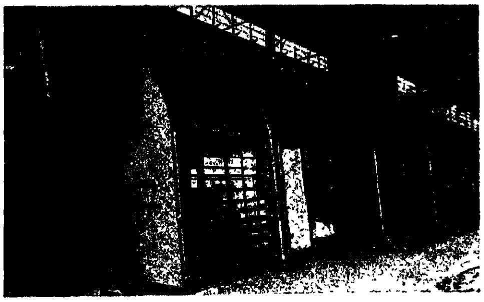


FIG. 9—21,000/(18,000)-KVA., 300-REV. PER MIN.. 25-(60)-CYCLE, ONE (THREE) PHASE, FREQUENCY-CONVERTER OUTDOOR HOUSING (W)—WAYNE JUNCTION SUBSTATION, PHILADELPHIA ELECTRIC CO.

A 90-kw., 3,600-r. p. m., direct-connected, turbine-generator exciter has been developed (W) which is one of the largest exciters ever built for this speed. (Fig. 11.)

Synchronous Converters

Four 5,440-kw., 167-r. p. m., 16,000-ampere, 25-cycle, synchronous converters were constructed (2 GE and 2 W) for a chemical plant in the Niagara Falls District. The converters are enclosed in volute housings, and the outgoing air is discharged outside the building. Direct-current voltage adjustment is obtained by means of tap-changing equipment on the supply transformers. A novel feature of construction used on two of these machines (GE) is a "tandem" commutator, which consists of two sets of shorter copper segments, together with insulation and clamping rings, mounted on a common support so arranged that air can pass between the adjacent ends of the two commutators where their segments are connected together. This construction (Fig. 12) results in lower temperature rise and smaller expansion strains and, consequently, a smoother running surface than is usually obtained with an equivalent single-unit commutator.

TRANSFORMERS

Power Transformers

Extensive theoretical and experimental study of transient voltage phenomena was continued during the year, and the development of means for protection against lightning surges advanced rapidly. One indication of the progress made during the year is given by the successful outcome of full voltage flashover tests on a large transformer.

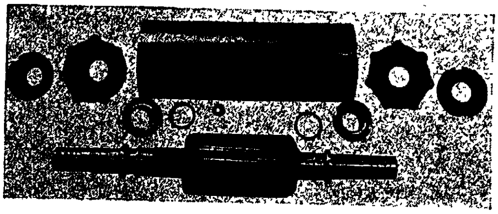


FIG. 10—40-LB.-FT., 250-VOLT, 125-REV. PER MIN., 25-CYCLE, CONVEYOR-ROLLER INDUCTION MOTOR (GE)

A 13,000-kva., 230-kv., wye-grounded, non-resonating transformer built for commercial use (GE) was subjected to a series of artificial lightning voltage tests. The transformer was connected to a lightning generator by a short transmission line insulated with fourteen 10-in. units, spaced 5¾ in. in suspension, which is used quite generally for 230-kv. service. The insulator strings were repeatedly flashed over without apparent damage to the transformer. The line insulation was then increased until the transformer bushings were flashed over. The transformer was subjected to repeated waves both above and below the bushing flash-over voltage, after which it withstood all A. I. E. E. standard tests.

A study of transient voltage phenomena within auto-transformer windings resulted in the development of the non-resonating auto-transformer (GE), of which several have now been built for 230-kv. service.

Through the development of the grounding neutral impedor (GE), the use of the non-resonating transformer was extended to include banks with neutrals isolated or grounded through resistance or reactance.

Investigation (W) has shown that a comparatively high resistance can be used in the neutral of a bank of power transformers and the bank will perform practically the same as though it were solidly grounded. The same result can be obtained with reactance in the neutral paralleled by a protective device, such as a lightning arrester. The internal voltages at points within the winding have been found to be practically identical for a bank with a solidly grounded neutral and for one with a reactance paralleled by a lightning arrester.

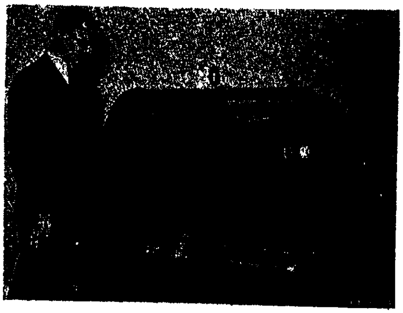


FIG. 11—90-KW., 3,600 REV. PER MIN., DIRECT-CONNECTED, TURBINE-GENERATOR EXCITER (W)

In order to extend the benefits of load-ratio control to small transformers, a lighter type of equipment has been developed for 15-kv. service (GE). This consists of a multi-point switch which permits the load current to leave each tap point over two paths; *i. e.*, over two switch arms which connect to the bridging reactor. A typical application of this equipment is represented by a 3,333-kva., 69.7/115 Y-13.8-kv., one-phase transformer, in which thirteen operating positions are provided by the installation of the control device in the low-voltage winding. In this type of construction all moving parts, that is, the ratio adjuster and two contactors, are mounted outside the main transformer tank.

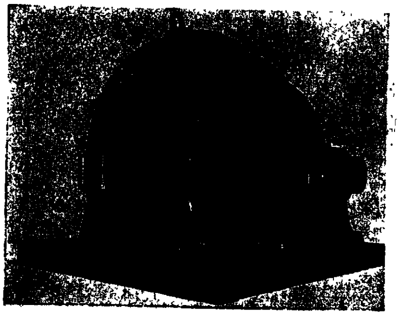


FIG. 12—5,440-KW., 340/270-VOLT, 16,000-AMPERE, 25-CYCLE, SHUNT-WOUND, SYNCHRONOUS CONVERTER WITH TANDEM COMMUTATOR AND BRUSHES (GE)

Several 5,000-kva., 13.2-kv., three-phase, furnace transformers, with a new type of tap-changing equipment, have been built (W) for the Ford Motor Company. These transformers deliver a normal low-voltage current of 12,800 amperes at 225 volts, with a maximum current of 19,200 amperes at 150 volts. A special motor-operated tap changer provides six different delta low voltages and a change from delta to star on the high-voltage winding gives six additional delta low voltages. Two individual tap changers are operated by one motor and all the voltages and connections are obtained by the operation of a single control switch at the switchboard.

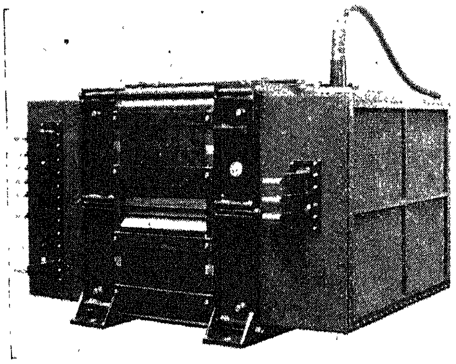


Fig. 13—4,200 Kva., 11,000,-915-46 Volts, 25-Cycle, Air-Blast, Locomotive Transformer (GE) (W)—Pennsylvania R. R.

A 4,200-kva., 11,000-915-46-volt, air-blast transformer of special construction was built (coordinated design of GE and W) for installation in a locomotive where space is at a premium. (Fig. 13.) It was, accordingly, designed for minimum dimensions and weights, the floor space occupied being 6 ft. 8 in. by 7 ft. 3 in. and the total weight being approximately 26,000 lb. A 2,800-kva. transformer of the same type has also been developed. These transformers are suction air-cooled and of exceptional mechanical strength, being braced and insulated for the severe operating conditions incident to locomotive service.

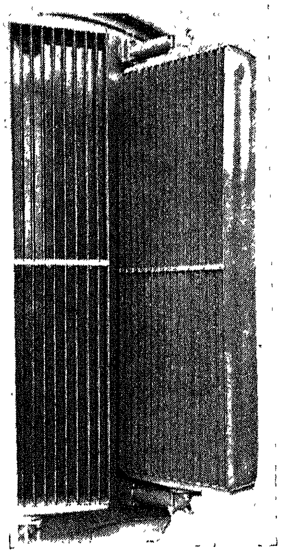


Fig. 14—Outside-Edge-Welded Transformer Radiator (W)

Power-Transformer Auxiliaries

While the method of cooling transformers by means of "banked" radiators was not used to any great extent following its development several years ago, it was extensively applied during the past year. About 200,000 kva. in transformers of this construction are in service and more than 600,000 kva. are now under construction (GE).

A new type of transformer radiator has been developed to replace the tubular type on all Westinghouse large self-cooled power transformers. (Fig. 14.) All of its joints are formed with edge welds on the outside of the radiator, and there are no crevices or flat surfaces where water can accumulate. The open construction facilitates cleaning and painting.

A 20,000-kva., 66-22-kv., load-ratio-control transformer, equipped with unusual pothead disconnecting switches has been built (W) for the State Line Generating Company. These high-voltage switches disconnect the transformer from the line and connect test bushings to the 66-kv. cable lines, which can then be tested with 330 kv., direct current. The pothead equipment also included oil reservoirs used to maintain pressure on the oil-filled cables to which the transformer is connected.

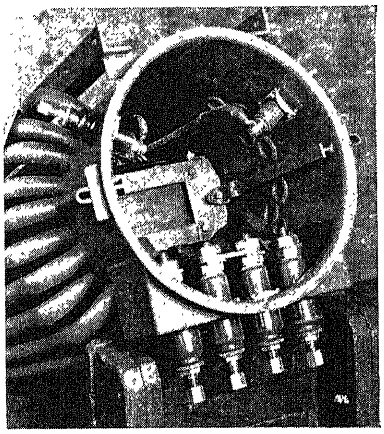


Fig. 15—100-Kva., 2,080-115/230-Volt, 60-Cycle, Distribution Transformer Equipped with Detachable Bushing (AC)—Commonwealth Edison Co.

A new no-load ratio adjuster has been developed (BB) which is operated through the side of the tank wall instead of the cover, making it more convenient to operate and permitting the tap position to be safely checked without deenergizing the transformer. A novel form of connection is used between the internal and external parts which permits engagement or disconnection of the two parts, when the transformer core is tanked or untanked, without the necessity of crawling inside to remove pins, bolts, etc.

Distribution Transformers

A new single-bushing, single-phase transformer has been designed (GE) for 110-kv. rural service. It is arranged for connection from line to neutral on a 110-

kv. circuit, which is insulated for 132-kv. service. In order to secure a low over-all height, the interior was so constructed as to give the equivalent of an inverted winding. The bushing was then connected to the bottom of the coil stack, thereby effecting a low height in spite of the large size of the bushing and the amount of insulation required for operation on a 132-kv. insulated line.

A detachable bushing has been developed (AC) for distribution transformers, particularly for installation where lightning conditions are abnormally severe, which can be replaced without removing the case from the pole. (Fig. 15.)

Rectifiers

The installation of rectifiers has continued to increase at a rapid rate, particularly when measured in terms of the aggregate kw. capacity.

	No.	Kw.
Put into operation during 1930	33	75,225
Put into operation during 1929	30	48,125
Increase	10%	58%
Put into operation during 1930	33	75,225
Being erected during 1930	26*	71,400*
On order at end of 1930	29	79,275
Total for 1930	88*	225,900*
In service at end of 1929	90	102,309
Grand total	178*	328,209*

*In addition one spare 500-kw. rectifier tank (without transformer) was supplied.

The mercury-arc rectifiers put into operation and being erected during 1930 and on order at the end of the year are shown in Table III.

The placing in operation of fourteen units with an aggregate rating of 40,000 kw. of 3,000-volt rectifiers

TABLE III—MERCURY-ARC RECTIFIER UNITS PUT INTO OPERATION DURING 1930 OR ON ORDER DECEMBER 31, 1930

Purchaser	No. of sets	D-c. volts	Kw. per set	Total kw.	Control	Service	Put in service	Manufacturer
American Gas & Electric, New York	2	610	500	1,000	Automatic	Railway	On order	Brown-Boveri
Boston Elevated Railway	2	600	3,000	6,000	Automatic remote control	Railway	Being erected	General Electric
Chil Exploration Co	1	650	1,000	1,000	Automatic	Heavy mine haulage	1930	General Electric
Clinton, Davenport & Muscatine Railway	1*	700	500	500*	Automatic	Railway	Being erected	Brown-Boveri
Commonwealth Edison Co	2	1,500	1,500	3,000	Manual	Railway	1930	Brown-Boveri
Commonwealth Edison Co	4	625	3,000	12,000	Manual	Railway	1930	Brown-Boveri
Commonwealth Edison Co	3	625	3,000	9,000	Manual	Railway	Being erected	Brown-Boveri
Commonwealth Edison Co	3	625	3,125	9,375	Manual	Railway	Being erected	General Electric
Consolidated Mining & Smelting Co. of Canada	2	650	6,500	13,000	Manual	Electrolytic	On order	Brown-Boveri
Consolidated Mining & Smelting Co. of Canada	1	650	6,500	6,500	Manual	Electrolytic	On order	General Electric
Delaware, Lackawanna & Western R. R. Co.	12	3,000	3,000	36,000	Manual	R. R. electrif'n	1930	General Electric
Delaware, Lackawanna & Western R. R. Co.	2	3,000	2,000	4,000	Automatic remote control	R. R. electrif'n	1930	General Electric
Detroit, City of	1	600	2,000	2,000	Automatic	Railway	On order	General Electric
Edmonton, City of	1	575	1,325	1,325	Manual	Railway	1930	Brown-Boveri
Hershey Chocolate Company	1	600	500	500	Manual	Interurban-railway	1930	General Electric
I. G. Farbenindustrie for Standard Oil Co. of Louisiana	1	3,500/9,600	2,200	2,200	Manual	Electro-chemical	Being erected	Brown-Boveri
Iowa Nebraska Light & Power Co	1	600	1,000	1,000	Manual	Railway	1930	Brown-Boveri
Italian Stat Railways	2	2,900	2,000	4,000	Automatic	R. R. electrif'n	1930	General Electric
Long Island Railway Co	5	650	3,000	15,000	Automatic	Railway	Being erected	Brown-Boveri
Los Angeles Railway Corp	2	600	1,500	3,000	Automatic remote control	Railway	On order	General Electric
Montreal Tramways Co	2	600	1,500	3,000	Automatic remote control	Railway	Being erected	General Electric
Montreal Tramways Co	2	600	1,500	3,000	Automatic remote control	Railway	1930	General Electric
New York Board of Transportation	10	625	3,000	30,000	Automatic remote control	Subway	Being erected	General Electric
New York Board of Transportation	13	625	3,000	39,000	Automatic remote control	Subway	On order	General Electric
Northern Indiana Public Service Co	1	1,500	3,000	3,000	Automatic	Railway	Being erected	Brown-Boveri
Paris Orleans Railway, France	1	1,500	1,500	1,500	Automatic	R. R. electrif'n	On order	General Electric
Philadelphia, City of	2	630	2,500	5,000	Manual	Subway	1930	Brown-Boveri
Public Service Co. of No. Ill., Chicago	1	600	1,900	1,900	Manual	Railway	1930	Brown-Boveri
Public Service Co. of No. Ill., Chicago	1	600	1,900	1,900	Automatic	Railway	1930	Brown-Boveri
Quebec Power Co	1	550	1,200	1,200	Automatic	Railway	Being erected	Brown-Boveri
Regina, City of	1	575	1,200	1,200	Manual	Railway	On order	Brown-Boveri
Saskatoon, City of	1	575	600	600	Automatic	Railway	1930	Brown-Boveri
Trenton Transit Co	3	600	1,400	4,200	Manual	Railway	On order	Brown-Boveri

Totals:		
Put in service	33	75,225
Being installed	26*	71,400*
On order	29	79,275
Grand total for year	88*	225,900*

---

*In addition one spare 500-kw. rectifier tank (without transformer) was supplied.

on the Delaware, Lackawanna & Western Railroad Electrification (Fig. 16) was the outstanding event of this year. This is the first installation of 3,000-volt rectifiers in the United States and the first use anywhere of so great a capacity of such units. It is also the first instance of a major railroad electrification relying entirely on rectifiers for the supply of power. These rectifiers are equipped with excited grids and with automatic compounding.

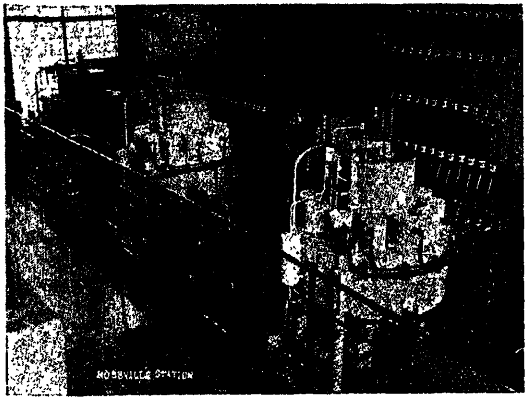


FIG. 16—3,000-KW., 3,000-VOLT, MERCURY-ARC RECTIFIERS (GE)—ROSEVILLE SUBSTATION, DELAWARE, LACKAWANNA & WESTERN R. R. ELECTRIFICATION

Another outstanding feature is the very large number of units ranging in voltage from 550 to 650 volts with a current rating in excess of 3,000 amperes, notable among which are 23 sets (GE) with an aggregate capacity of 69,000 kw. on order by the New York Board of Transportation. (The first seven units of this order were reported last year under the heading "City Subways of New York.")

Five units (BB), having a normal rating of 4,650 amperes at 650 volts, with overload ratings up to 15,000 amperes for twenty seconds, are being erected for the Long Island Railroad (Fig. 17). These rectifiers have eighteen anodes and normally operate from a 25-cycle source of supply but are arranged for immediate throw-over to a 60-cycle source of supply in the event of failure. The transformers are also suitable for operation at either 11 or 33 kv.

A 2,200-kw., high-voltage electric furnace set is also being erected (BB). The d-c. voltage may be varied from 3,500 to 9,600 volts by means of load-ratio control on the rectifier transformer. This is the highest voltage for commercial rectifiers which has been reported in this country. Smaller units of higher voltage have, however, been used for large radio broadcasting stations in Europe.

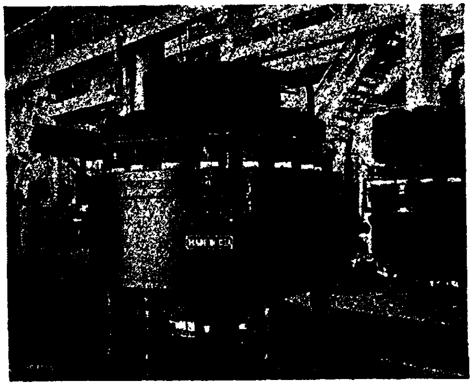


FIG. 17—3,000-KW., 650-VOLTS, MERCURY-ARC RECTIFIER (BB)—LONG ISLAND R. R.

Electrochemistry and Electrometallurgy

ANNUAL REPORT OF COMMITTEE ON ELECTROCHEMISTRY AND ELECTROMETALLURGY*

THIS report covers the period 1929 and 1930, inasmuch as no report was made in 1929.

It is believed worthwhile to indicate the magnitude of the electrochemical and electrometallurgical industries in terms of installed capacity and yearly power consumption. The figures for the United States are as follows:

Approximate installed operating capacity, kw	7,000,000
Approximate percentage of National total generating capacity	18
Approximate annual power consumption, kw-years	4,900,000
Approximate percentage of total	36
Number of workers	1,000,000
Value of product	$12,000,000,000

Quantities and percentages such as these would seem to warrant the liveliest interest on the part of men having electrical engineering training, particularly the younger men who find themselves faced with limited opportunities for advancement in those more standardized fields of the electrical art involving the design and manufacture of apparatus for the production and distribution of electrical energy. The development of new materials or processes based upon the utilization of this power is a field requiring talent of high order and one which it seems should be very attractive to men of electrical training who can and will superpose on an electrical background a knowledge of the fundamentals of physical chemistry.

Below is given a list of the more important industries whose basic processes are dependent upon the utilization of electricity for other than mechanical purposes:

Production of Metals by Wet Electrolysis. Copper, Nickel, Sodium, Zinc.

Production of Metals from Fused Electrolytes. Aluminum, Barium, Beryllium, Calcium, Magnesium.

Non-Metallic Electrolytic Products. Caustic, Chlorine, Hydrogen, Oxygen.

Electrothermic Products. Abrasives, Carbides, Carbon, Ferro-Alloys, Graphite, Refractories.

Miscellaneous. Cleaning and Surface Treatment of Metals, Dry Cells, Electric Steel Melting, Electrolytic Synthesis Organic Compounds, Electroplating, Electrostatic Precipitation, Inductive Melting and Heating, Nitrogen Fixation, Pasteurization and Sterilization, Secondary Batteries, Water Purification, Welding.

When the process problems of these industries are analyzed it will be found that they should be attacked by men who have been trained to deal with intangibles, and that most of the phenomena may be resolved into elements among which an electrical engineer who has been soundly trained in the basic science of his art should feel at home. Pursuit of these problems will probably lead him far from consideration of the newest thing in circle diagrams or the latest refinement in slot design but he will have broader scope for his imagination and the mental technique bred by electrical training.

The foregoing comments have been made because there are many who feel that the electrical industry is more in need of increased outlet for power than of further small gains in the efficiency of electrical apparatus *per se,* and that the great body of expectant young electrical engineers must look for adequate opportunities for advancement more to the fields of utilization and electrical processes than to the conventional ones of apparatus and generation.

Below is given an outline of the more important developments in electrochemical and electrometallurgical art that have become known during the past two years.

Copper

Although copper refining is probably the largest of the electrochemical industries in point of tonnage, no important modifications of electrochemical process have been reported although operating economies have been improved by advances in mechanical equipment and materials handling facilities.

Sodium

Metallic sodium is now being produced on such a large scale and so cheaply by electrolytic methods that it is the cheapest pure metal in terms of cost per unit volume. Its electrical conductivity is high enough so that its cost on a conductivity basis is lower than that of any other metal. These facts have led to a proposal that electrical conductors be formed of metallic sodium enclosed in a thin-walled tube of some non-magnetic alloy steel.

Metallic sodium is finding increasing application in connection with certain synthetic organic reactions whose nature is not disclosed and certain electrochemical interests are said to be preparing to manufacture sodium on an unprecedented scale.

---

*COMMITTEE ON ELECTROCHEMISTRY AND ELECTROMETALLURGY:

P. H. Brace, Chairman,
Lawrence Addicks,
T. C. Atchison,
Farley G. Clark,
S. K. Colby,
J. C. Hale,
F. C. Hanker,
W. E. Holland,
F. A. Lidbury,
R. G. Mansfield,
O. E. Sisson,
H. Speight,
N. R. Stansel,
Magnus Unger,
G. W. Vinal,
J. B. Whitehead,
E. A. Williford,
J. L. Woodbridge,
C. D. Woodward.

Zinc

The success of electrolytic zinc refining plants was noted in the 1928 report of this committee. This development has since been subject to severe competition because of improvements in thermochemical methods. Electrothermal methods have also received the attention of investigators and it is probable that another year will see marked changes in zinc technology due directly to the application of electricity in one way or another.

Aluminum

The Hoopes process of producing very pure aluminum has become of increasing commercial importance, particularly for containers for various articles in the drug and pharmaceutical field. Although the electrical conductivity is appreciably higher than that of ordinary commercial aluminum it has not been commercially applied as electrical conductor material. Accurate alloy investigations have been made possible by this very pure material and the knowledge thus gained has assisted materially in the development of the strong aluminum alloys.

The usual Hall process rarely produces aluminum purer than 99.7 per cent, while the Hoopes process is regularly producing metal better than 99.98 per cent pure and some metal has been produced by this process having a purity of 99.99 per cent. The process is carried out in a three-layer cell, wherein the metal to be purified exists as a molten anode alloy and rests on the bottom of the cell. The electrolyte consists of a mixture of cryolite, aluminum fluoride and barium fluoride. The purified aluminum is electrolytically deposited in a layer of pure molten aluminum floating on top of the electrolyte. Graphite electrodes are employed to lead the current out of the aluminum layer. The cell operates at a voltage varying from 5 to 7 volts and normally a current of 20,000 amperes is employed.

By anodic treatment in wet electrolytic cells aluminum may be given a tough, adherent and corrosion resistant surface of oxide which serves as a base for color and which is also finding use for protection of aluminum alloy aircraft structure from severe corrosion attack such as that of salt spray and sea-water. This development is still going forward rapidly and is expected to become of much greater importance in aluminum technology.

Electro-plating with aluminum on copper and other base metals has been accomplished by the use of a fused electrolyte of low melting point comprising the chlorides of aluminum and sodium. Tough, adherent, and non-porous deposits of pure aluminum are produced and many commercial uses will no doubt be found as the technique is improved.

Barium

Barium is one of the alkaline-earth elements and is characterized by great reactivity and interesting thermionic properties. It is produced by the electrolysis of fused barium salts and has been receiving considerable attention because certain of its alloys have useful thermionic properties. It has found commercial application in a nickel-base alloy for spark plug electrodes and has been of interest as an essential constituent of alloys intended for use as cathodes in thermionic devices. Such barium alloys are, in general, electric furnace products.

Beryllium

During the past few years the metal beryllium has received a great deal of attention, which has been primarily due to the results of systematic research both in this country and abroad. Beryllium may be produced by an electrolytic process which consists of the electrolysis of mixed beryllium oxyfluoride and barium fluoride. The only commercial ore of beryllium is a silicate of beryllium and aluminum. The beryllium oxide content of available ores lies between 6 and 12 per cent. The production of beryllium has been carried out both in this country and abroad.

The future of beryllium does not appear to lie in its use as a basic material, but rather as a minor constituent in more or less complex alloys.

About the only use thus far developed for the pure metal is as windows in X-ray tubes, inasmuch as beryllium is extremely transparent to X-rays. Experimental use in pistons and piston rings has been reported. Continued research will doubtlessly develop new uses for this interesting metal, inasmuch as it possesses a combination of high elastic modulus, low expansivity and lightness which is very attractive to many who are interested in mechanical developments. Its electrical resistivity is approximately 6.7 microhms per cu. cm. at room temperature.

Magnesium

This metal is produced by the electrolysis of molten magnesium chloride and more recently by means of processes in which magnesium oxide is dissolved in a bath of fused fluorides and decomposed by electrolysis to give the metal. The production of magnesium in the United States has increased from approximately 50,000 lb. in 1921 to more than 1,000,000 lb. in 1930. During 1930 magnesium forgings have appeared on the American market and with continued research it is expected that increased quantities of strong magnesium alloys in the form of castings and forgings will be rather extensively employed particularly in aircraft. With improved production technique purer metal is being produced and the susceptibility to corrosion lessened in consequence.

The outstanding difficulty in the way of increasing the use of magnesium has been the development of suitable alloys and fabricating processes and great strides are being made in this direction.

Electrotechnology of Gases

The treatment of gaseous mixtures by electrical discharges in order to effect chemical reactions that would not ordinarily occur has received a great deal of attention. The work of Fischer and Peters in Germany is particularly interesting in that they find it possible to produce acetylene from methane with an energy consumption that compares favorably with that required by the conventional calcium carbide process. The cracking of heavy hydrocarbon vapors by corona discharge also shows some possibilities. A great deal of research is going on in connection with the chlorination of hydrocarbons such as methane, pentane, etc., and this promises a considerable expansion in the use of chlorine, which is an electrolytic product. Research investigations of the chemical effects of bombardment by high-speed electrons should also be mentioned.

Abrasives—Carborundum

Tungsten carbide cutting tools have found increasing application and this has necessitated the development of improved abrasive wheels for shaping them. As a consequence special grades of carborundum are being made, apparently of unusual purity, from which grinding wheels specially adapted to the shaping of carbide tools are made. Carborundum base resistors for high temperature electric heating furnaces have been considerably improved, and several manufacturers have designed about this type of resistor commercial furnaces for operating temperatures between 1,000 deg. and 1,400 deg. cent.

Aluminum silicate refractories of very high melting point are being fused in electric furnaces and cast into blocks and shapes for various purposes, particularly for parts for glass-melting furnaces. The melting and casting of such highly refractory substances is a new and interesting departure in industrial ceramic technology.

Cleaning of Metals

A wet electrolytic process for the removal of scale from metals which is said to be competitive with pickling and free from many of its objections has been put on a commercial basis. Hydrogen embrittlement is prevented by the automatic deposition of a thin film of lead on any area of clean metal as soon as it is exposed by scale removal. This lead film may be allowed to remain as a protection against corrosion or removed by anodic oxidation by reversal of the electrolyzing current.

Electrochemical Standards

The interest in our electrochemical standards for the international ampere and the international volt has been continued and during the coming summer cooperative measurements on these standards will be carried out at the Physikalisch-Technische Reichsanstalt. For this purpose Dr. G. W. Vinal, Chief, Section of Electrochemistry, U. S. Bureau of Standards and a member of this Committee is being sent to Germany. He will also make measurements at the Laboratoire Central d'Electricite in Paris, and the National Physical Laboratory in England.

Primary and Secondary Batteries

During the past year the American standard for dry cells has been revised and a new standard approved by the American Standards Association. This standard has been published by the Association and also by the Bureau of Standards as Circular No. 390. The technical requirements of the Government specifications are identical with those of the American standard, but the Government specification is being revised to accord with the form prescribed by the Federal Specifications Board for all Government specifications.

The Federal specifications for automotive storage batteries have been approved and published during the year. These are designated as W-B-131 and are contained in section 4, part 5 of the Federal Standard Stock Catalog.

The past twelve months have witnessed a considerable decline in the demand for primary battery products in general due to the business depression and the reduction in the number of battery operated radio sets in active use. This has naturally affected most the production of B batteries, though the production of 6-in. dry cells, many of which were also used for radio, has been seriously affected as well. The demand for flashlight batteries seems actually to be on the increase due perhaps to the appearance on the market of a rather wide variety and a considerable number of inexpensive flashlight cases which have apparently been widely bought.

The general decrease in demand for battery products has resulted in a tendency to reduce prices and on the part of at least the larger manufacturers to strengthen quality. Many of the smaller manufacturers have been forced out of the business as a natural consequence.

The year has brought the development of the industrial flashlight battery intended for use by public service corporations, railroads, theaters, and manufacturing organizations where the demand on the battery is considerably heavier than in ordinary flashlight use. At a recent conference at the Bureau of Standards two tests were standardized as representative of the industrial types of service and this has greatly facilitated and intelligently guided the development of satisfactory cells for this specific application.

Special radio B batteries of superior performance have been developed in response to demand created by radio-equipped automobiles for police squad use as well as for privately owned machines.

In the 6-in. dry cell group there has been a further advance in the life of the better telephone cells. Certain makes have reached the remarkably high figure of 360 days on the standard light intermittent test which compares with a maximum of about 180 days ten years ago.

An interesting new development which has occurred in the primary battery field during the past year is the introduction by one manufacturer of an air depolarized portable caustic soda battery designed primarily for use as an A battery for specially designed radio receivers using the new two-volt tubes and operated entirely by batteries. It is hoped that radio receivers of this type will develop wide application in rural districts where power is not available for operating electric radio sets and where storage batteries cannot be conveniently charged. This so-called air cell radio A battery is said to be good for a year's average service with one of these receivers. The basis of its operation is the absorption by a porous carbon electrode of the oxygen from the air which is carried to the surface of the electrolyte where it acts as a depolarizer for the cell. While the principle employed is not a new one, its application to a portable practical battery is believed to be new.

During the year, the revised American Standard for Dry Cells has been published, both by the American Standards Association of 29 West 39th Street, New York City, and by the Bureau of Standards in its Circular No. 390.

In the field of storage batteries the recent publication of the Federal Specification for Automotive Batteries, designated as W-B-131, may be mentioned.

A new storage battery, the Drumm alkaline cell, which involves the use of an electrolyte of potassium hydroxide with electrodes of nickel and other substances not disclosed, is said to provide reduced weight, increased efficiency, and the possibility of recharging in a 30 minute period. The e. m. f. is 1.5 volts. Successful trials in heavy trucking service are reported from England.

Electric Melting Furnaces

The demand for better metallurgical performance of arc furnaces is bringing about refinements in control gear among which are the use of tap-changing transformers to enable more precise voltage control and a tendency toward the adoption of hydraulic drive for electrodes, in which pilot valves responsive to furnace current, voltage or kva. operate to control fluid flow to the electrode driving cylinders. More prompt response, improved sensitivity and absence of hunting are said to be provided by hydraulic operation.

Induction furnaces of the submerged ring type are finding somewhat wider application owing to improvements in refractories and in a few places abroad have been used on high-nickel alloys and for superheating cast iron for high-strength castings.

Coreless induction furnaces operating at high frequency have found commercial application in sizes up to two tons, with power ratings up to 600 kw. High-frequency generating units of 1,250 kw. are being built to supply 3½ ton furnaces. A common frequency is 980 cycles, but the trend is downward, particularly for large units. Commercial frequencies have been successfully applied and one manufacturer has successfully operated experimental four-ton units at 60 cycles, the entire kva. requirement being supplied by a motor-generator set. Considerable attention has been given to the technique of refining in these induction furnaces and some success has been attained.

Oxygen-free copper from large inductively heated furnaces is a commercial possibility of the near future. Such a material would avoid some of the weaknesses of present commercial copper and in particular its tendency to embrittlement when subject to hot reducing gases. Unusually high ductility may make it interesting for some mechanical uses.

Control of furnace atmosphere, vacuum melting, and the distillation of metals are all receiving attention at the hand of investigators.

Water Purification

Electrolytic purification of water has been receiving considerable attention following the announcement, in Germany, of a process and apparatus in which water is passed through a succession of diaphram type electrolytic cells which cause concentration of ionogens in the electrode compartments. It is susceptible of large-scale operation but so far has been used mainly to complete the purification of distilled water.

Sterilization of Milk

The electropure process of milk conditioning effects pasteurization by passing the raw milk rapidly between carbon electrodes where it is heated by the passage of 60-cycle current. This scheme enables refinements in the control of the time and temperature variables that have hitherto been impracticable and the quality and uniformity of the product are thereby enhanced.

Electrostatic Precipitation

The results of test of improved hot-cathode vacuum rectifiers indicate that it will be possible to improve the operation and decrease the physical dimensions of the electrical end of precipitation plant. Increased use of powdered coal firing has caused the ash which is carried up the stack to be troublesome and electrostatic precipitator equipment is finding application in this connection. The same fundamental ideas are being applied to the separation of suspended solids from liquids. The purification of insulating oils is a case in point and it is stated that by electrostatic cleaning higher breakdown values can be obtained than by methods now in general use.

Metal Powders

Finely divided metals find numerous uses in chemical technology and as pigment in the decorative arts. Electrolytic means have been developed for producing copper, tin, nickel, silver, and lead in crystalline form in sizes as fine as 500 mesh.

MISCELLANEOUS PROCESS AND PLANT

Mercury-Arc Rectifiers

There are under construction for a Canadian Plant mercury-arc rectifiers rated at 6,500 kw. each (10,000 amperes, 650 volts) to be used for the electrolytic production of hydrogen.

Rotary Converters

Another electro-chemical plant has installed synchronous converters with load ratio control type transformers to furnish direct current for an electrolytic process. These machines are rated at 5,440 kw. each (16,000 amperes, 340/370 volts). These machines are also of interest because of their use of volute housings as part of the ventilation system.

Electrodeposition of Tungsten

The electrodeposition of tungsten in the wet way from alkaline baths has been accomplished on a laboratory scale. Tungsten possesses such marked resistance to acid attack and to wear that this development may prove to be of considerable industrial importance.

Heat Treating Furnaces

A marked interest was shown by the steel industry in the use of electric furnaces for heat treatment service. One plant installed two 1,100-kw. resistor type furnaces 50 tons capacity each, one 1,000-kw. similar furnace, and other furnaces, making a total of 4,500 kw.

The use of artificial atmospheres in electric furnaces for heat treatment processes is making considerable progress. One steel plant has installed 2,000 kw. in furnace capacity for bright annealing of steel strip.

Electrically heated and controlled apparatus for controlling the composition of the gases used are coming into evidence.

The special requirements of the nitriding process which involves heating to approximately 550 deg. cent. articles of special alloy steel (containing small amounts of Cr, Al, Mo, and Ni) in an atmosphere of ammonia has led to the development of furnaces with special provisions for circulating the ammonia. Heat transfer is effected by forced convection instead of by radiation. It appears possible that the application of this principle will find extended application in special-purpose furnaces in which control of atmosphere is important.

In both the heat-treating and melting fields the refinements of metallurgical technique and the growing recognition of the value of high quality and uniformity of product have brought about such profound changes in the design and operation of furnaces that they are coming to resemble machine tools rather than the piles of brick that the word usually calls to mind.

CONCLUSIONS

It is believed that this report reflects the more important trends in electrical process technology and hoped that it may draw the attention of electrically trained men to the very interesting possibilities in the field of the development of processes and materials dependent upon the forces that only electricity can bring into play.

The Chairman wishes to acknowledge the assistance given by members of the Committee and by numerous individuals in the preparation of this report which is respectfully submitted on behalf of the Committee on Electrochemistry and Electrometallurgy.

Electrophysics

ANNUAL REPORT OF THE COMMITTEE ON ELECTROPHYSICS*

THE annual report of the Committee on Electrophysics has generally taken the form of an account of the progress in the field of electrophysics during the preceding year. In view of the steady increase of the activity in this field the matter to be covered has increased greatly, and the report for the year 1929-1930 was a lengthy one in spite of all efforts to keep its size down to a minimum.

At a meeting of the committee held January 30, 1931 its field of activity and in particular its annual report were discussed at considerable length. It was the sense of the committee that it was one of the most important of its functions to bring to the attention of electrical engineers the progress being made in electrophysics. It was felt very strongly, however, that this cannot be done in the best possible fashion by reporting the progress for a year at one time and publishing it as a unit. Accordingly, the committee decided that it could be of much greater service to the engineering profession if its reviews of the progress in electrophysics were published from time to time by subjects instead of annually as a unit. As a result the plan was adopted of publishing reviews of the progress of electrophysics by subjects in ELECTRICAL ENGINEERING. Each contribution will aim to cover the progress in its particular field from the date of the preceding report as nearly up to the date of publication as is possible. A tentative schedule of the proposed subjects is as follows:

Magnetism and Magnetic Materials.
Propagation of Electric Waves.
Electric Discharges in Gases.
Dielectrics.
Thermionics and Photoelectricity.
Vacuum Gas Discharge and Photoelectric Tubes.
Electric Conduction in Solids.
Electromagnetic Theory.

In addition the Committee plans to sponsor from time to time for publication in ELECTRICAL ENGINEERING papers by recognized authorities on various subjects in electrophysics of interest to electrical engineers. One such paper is published herewith. After all the reviews for any one year have been published, they may be collected and published together in the TRANSACTIONS if it should be considered desirable.

Magnetism and Magnetic Materials

The following review of progress in magnetism and magnetic materials covers the period since the last report of the Electrophysics Committee. The progress in other phases of electrophysics will be covered similarly in succeeding reviews. The Committee also may offer from time to time papers on subjects in electrophysics of interest to electrical engineers.

MAGNETISM

Our understanding of ferromagnetism has advanced during the period since our last report (JL. A. I. E. E. 49, 721, 1930) in several important respects. Heisenberg's interaction theory, which refers the stability of magnetization to the low potential energy of codirected electron spins in neighboring atoms, has been applied by Powell (*Proc. Phys. Soc.* 42, 390, 1930) to explain the change in dimensions which take place when iron and nickel lose their ferromagnetism on heating. This change, a decrease in the case of iron, an increase in the case of nickel, is isotropic, being thus wholly unlike the principal part of magnetostriction which differs greatly in different crystallographic directions. It is concluded from the fact that both signs of change occur that some account must be taken, at least in the case of iron and probably in all cases, of atoms more remote than the immediate neighbors. Becker and Kirsten (*Zeitsch. f. Physik* 64, 660, 1930) who identify the stabilizing forces with internal elastic strains, have succeeded in getting rather good agreement between the permeability of highly stressed nickel as measured and as calculated from limiting magnetostriction and the elastic moduli. Rankin (*J. Roy. Tech. Coll.* Glasgow 2, 385, 1931) has continued his experiments on magnetostriction in overstrained metals. Akulov has continued his discussions of the relations between magnetostriction, magneto-resistance and elasticity concluding in his latest papers (*Zeitsch. f. Physik* 67, 794, 1931; *Phys. Zeits.* 32, 107, 1931) that the magnetic behavior of single crystals is fully explained by a dual process of reversals and rotations of the magnetic elements and that the magnetic properties of polycrystalline metal *without large scale anisotropy* can be calculated from data obtained for monocrystals. McKeehan (*Rev. Mod. Phys.* 2, 477, 1930; 3, 190, 1931) has reviewed the content and relations between the current theories of ferromagnetism and some of the recent experimental evidence pertinent thereto.

Several papers, in addition to that of Powell, already referred to, deal with the experimental and theoretical

---

*COMMITTEE ON ELECTROPHYSICS:
Oliver E. Buckley, Chairman,
V. Bush,
W. G. Cady,
W. F. Davidson,
C. L. Fortescue,
W. S. G rton,
W. B. Kouwenhoven,
G. M. J. Mackay,
K. B. McEachron,
L. W. McKeehan,
H. Nyquist,
Leigh Page,
W. S. Rodman,
J. Slepian,
W. F. G. Swann.

aspects of the Curie point. Tyler (*Phil. Mag.* [7] **11**, 596, 1931) shows that the decrease of apparent saturation values with rise of temperature is practically according to the same law for iron, cobalt, and nickel, and that this is consistent with the idea that in all three metals single spinning electrons are free to change their axial direction, although in all these cases the average number of such magnetizable electrons per atom is greater than one. According to these data, therefore the ferromagnetic unit is sub-atomic rather than atomic. Above the Curie point it appears (Stoner, *Phil. Mag.* [7] **10**, 27, 1930) that atoms begin to act as units. Forrer and Hoffmann (*Comptes Rendus* **191**, 1046, 1930) present new evidence for a doubling of the (ferromagnetic) Curie point in nickel, the coercive force first decreasing, then increasing, and finally decreasing again as the temperature rises. An apparent disagreement between two experimenters, Weiss and Bates, in regard to the temperature at which the specific heat anomaly becomes greatest as the Curie point is approached has been dissolved by new evidence. Bates (*Proc. Phys. Soc.* **42**, 441, 1930; **43**, 87, 1931) now also finds this temperature to be where $-dI^2/dT$ is maximum; his earlier experiments were vitiated by an irreversible change in the properties of his material (manganese arsenide) produced by the small rise in temperature (magneto-caloric effect) associated with applying the magnetizing field. Incidentally, the specific heat anomaly is here far too large to be ascribed to an elementary magnet like that in iron or nickel.

The anomalous temperature coefficient of electrical resistance for ferromagnetics near their Curie points is closely associated with their magnetizability. Gerlach (*Zeitsch. f. Physik* **59**, 847, 1930; *Ann. der Physik* [5] **6**, 772, 1930) and Borelius (*Ann. der Physik* [5] **8**, 261, 1931) present opposing opinions regarding the anomaly. The former in agreement with earlier work of Cabrera regards the high-temperature state (above the Curie point) as normal and the low-temperature state as possessing an abnormally low resistance, the latter supports the contrary view that it is the low-temperature or completely magnetized state which has normal resistance. The transition as the Curie Point is approached from below is the same whichever view is taken.

The closely related subject of heat production during magnetization and demagnetization has been examined in a preliminary way by Gilbert (*Comptes Rendus* **191**, 1309, 1930) who finds no cooling in cobalt steel at H up to 18,000 except that attributable to the magneto-caloric effect of Weiss. The more complete report of Ellwood's results (*Phys. Rev.* [2] **36**, 1066, 1930) confirms his earlier finding of a cooling in carbon steel at low values of H on the ascending branch of a loop, and announces a second stage of cooling at moderate values of H. It should be noted that the magneto-caloric effect would account only for a minute heating in this part of the loop.

An effort has been made by Bitter (*Phys. Rev.* [2] **37**, 91, 1931) to coordinate ferromagnetic behavior with the small scale imperfection of metallic crystals recently predicted by Zwicky (*Helvetica Physica Acta* **3**, 269, 466, 1930; **4**, 49, 1931). Frenkel and Dorfman (*Nature* **126**, 274, 1930) deal with the same problem on purely thermodynamic principles, deciding that a large crystal cannot act as a magnetic unit.

Experiments on the Barkhausen effect in a rotating magnetic field (Cisman, *Ann. der Physik* [5] **6**, 825, 1930), make it more plausible than ever to suppose that the occurrence of a discontinuity in magnetization requires a definite degree of divergence between the applied field and the local magnetization. There is, in fact, a decided parallelism between Cisman's Barkhausen effects and hysteresis in rotating fields, most recently studied by Seiyama (*Mem. Kyushu Univ. Coll. Engg.* **5**, 227, 1930). Heaps and Bryan (*Phys. Rev.* [2] **36**, 326, 1930) have shown that large changes in magnetization and in magnetostriction are simultaneous. Bozorth has just discovered (*Nature* **127**, xxx, 1931) that in a very slowly changing magnetic field the Barkhausen discontinuities which can be detected by a high-speed oscillograph occur in closely grouped sets with quiet intervals between them. These compound events, in proximate analysis, can easily be mistaken for single events. This apparently explains the wide disagreement between published statements as to the volume of metal affected in a single discontinuity. The time required for the spreading of a major magnetic disturbance has been studied by Sixtus and Tonks (*Phys. Rev.* [2] **36**, 1441, 1930).

The gyromagnetic effect, hitherto only observed in ferromagnetic materials—most recently by Barnett (*Phys. Rev.* [2] **36**, 789, 1930)—has now been measured for a paramagnetic material by Sucksmith (*Proc. Roy. Soc.* [*A*] **128**, 276, 1930; *Proc. Phys. Soc.* **42**, 385, 1930). The phenomenon is merely easier to observe in ferromagnetics on account of their easier magnetization.

In studies on diamagnetic and weakly paramagnetic metals the theory has been improved by Landau (*Zeitsch. f. Physik* **64**, 629, 1930) and Teller (*Zeitsch. f. Physik* **67**, 311, 1931) so that better predictions are now possible as to the diamagnetism to be expected from conduction electrons. On the experimental side relatively enormous changes in susceptibility—much larger than the changes in conductivity make probable—have been reported by Honda and Shimizu (*Nature* **126**, 990, 1927) and by Bitter (*Phys. Rev.* [2] **36**, 978, 1930), both of whom measured the susceptibility of copper as affected by cold work and annealing. Banta (*Phys. Rev.* [2] **37**, 634, 1931) has attempted without success to duplicate Bitter's findings.

Spectroscopic evidence that some atomic nuclei have a small magnetic moment continues to accumulate (Fermi, *Zeitsch. f. Physik* **60**, 320, 1930; Goudsmit and Young, *Phys. Rev.* [2] **35**, 1418, 1930; Frisch and Ferchmin, *Naturwiss*, **18**, 866, 1930). The effect upon gross magnetic properties of such nuclear magnetic moments as have yet been shown to exist must be very small.

Effects of magnetic fields on electrical resistance and electric potential with or without the presence of thermal currents and temperature differences have been reviewed on the basis of the new electron theory of metals by Sommerfeld and Frank (*Rev. Mod. Phys.* **3**, 1, 1931). The proper mode of description of these galvanoelectric, thermoelectric, galvanomagnetic and thermomagnetic effects have been discussed by Perrier (*Helvetica Physica Acta* **3**, 317, 400, 1930). The conditions are especially complicated in the case of ferromagnetics. Pugh (*Phys. Rev.* [2] **36**, 1503, 1930) has shown for iron that the magnetization, I, or the ferromagnetic induction, B-H, is more important than either H or B in fixing the magnitude of the Hall e. m. f. Stierstadt (*Zeitsch. f. Physik* **65**, 575, 1930; **67**, 725, 1931) has studied magneto-resistance in electrolytic iron for both longitudinal and transverse magnetizations. Williams and Sanderson (*Phys. Rev.* [2] **37**, 309, 1931) present new data on magneto-resistance in nickel strips of different mechanical history.

The magneto-resistance of bismuth single crystals at extremely low temperatures, below 20 deg. K, has been studied in detail by Schubnikow and de Haas (*Nature* **126**, 500, 1930; *Proc. Amsterdam Acad.* **33**, 363, 418, 1930), who find a whole series of unexpected phenomena. Unlike the magneto-resistance at higher temperatures the relative change in resistance is no longer a smoothly varying function of the applied field, H, nor of the azimuth in any crystallographic plane yet examined. At higher temperatures, however, theory has caught up with experiment, for Frank (*Zeitsch. f. Physik* **64**, 650, 1930) has shown that the straightening out of $\Delta R/R$ *vs.* H curves at high H values, first observed by Kapitza, is completely accounted for by the quantum theory of electronic conduction. The parabolic increase of $\Delta R/R$, formerly supposed to be called for by the theory, is only possible for relatively limited ranges in H.

One of the most puzzling experimental results recently published is that of Allison and Murphy (*Am. Chem. Soc. Jl.*, **52**, 3796, 1930), who report that the magnetic double refraction (Faraday Effect) in certain solutions is characteristic, not only of the elements present but even of the number of isotopes of each, and furnishes a highly sensitive means for chemical analysis.

In the domain of magnetometry Sanford has been investigating magnetic permeameters, particularly those for use at high inductions (*Bu. Std. J. Res.* **4**, 177, 703, 1930; **6**, 355, 1931). A new level of precision in magnetic curve tracing has been attained by Haworth (*Bell System Tech. Jl.* **10**, 20, 1931; *Rev. Scient. Instr.* [N. S.] **2**, 125, 1931) who compensates the torque of a fluxmeter suspension by a photoelectric current depending upon the momentary deflection. Brüche (*Zeitsch. f. tech. Physik* **12**, 94, 1931) has considerably refined the methods for exploring magnetic fields by narrow beams of cathode rays. Freed and Kasper (*Phys. Rev.* [2] **36**, 1002, 1930) have improved the accuracy of Gouy's method for measuring the susceptibility of weakly magnetic solutions.

A stimulating book by S. R. Williams[1] gives a readable account of the experimental side of the subject of magnetism, with especial emphasis on ferromagnetism.

An important announcement regarding magnetic units as adopted by the International Electrotechnical Commission was made by Dr. Kennelly at the Winter Convention in New York. The electrophysics committee is by no means unanimously in accord with the suggestions of the international body. Some of our members feel that the already existing confusion in regard to the physical significance of B and H is increased rather than diminished by giving physical dimensions to their ratio. It is interesting to notice that a body of German engineers went even farther than the I. E. C. in the effort to rationalize empirical relations (*Elektrotech. u. Maschinenbau* **48**, 950, 1930).

MAGNETIC MATERIALS

The results of many investigations carried out in the past three or four years confirm the view that crystal grain size is one of the important factors in magnetic materials. Yensen (*Metals and Alloys*, **1**, 493-495; 1930) has proposed an expression for the hysteresis loss in iron in terms of the crystal grain size and impurities in the metal, leading to the conclusion that for perfect single crystals, free from impurities and internal strain, the hysteresis loss vanishes. Gerlach has more recently arrived at a similar conclusion. (*Zeitsch. f. Physik*, **64**, 502-506; 1930). On the other hand Von Auwers and Sizoo (*Zeitsch. f. Physik*, **60**, 576-580; 1930) conclude that crystal grain size has much less influence on remanence than on hysteresis loss and coercive force.

What promises to be of great importance is the announcement by Cioffi (*Nature*, **126**, 200-201; 1930) that ordinary polycrystalline iron may be made to acquire very high permeability by heat treating at high temperature in hydrogen. The reported initial and maximum permeabilities are 6,000 and 130,000, respectively, and the coercive force and hysteresis loss are respectively 0.05 gauss and 300 ergs/cu. cm./cycle, for $B_m = 14{,}000$. Later unpublished values give 180,000 for the maximum permeability, 0.025 gauss for the coercive force and 190 ergs/cu. cm./cycle for the hysteresis loss for the same maximum induction. These properties are ascribed partly to purification of the iron and partly to the hydrogen actually absorbed in the metal. Further correlation appears to be necessary between crystal grain size and magnetic properties in view of these results, since the grain size of this material appears to be of little importance.

The existence of the A_3 point in carefully purified iron occurring reversibly between 907 deg. cent. and

---

[1] "Magnetic Phenomena," McGraw-Hill, 1931.

910 deg. cent. has been confirmed by Roberts and Davey (*Metals and Alloys* **1**, 648-654; 1930), by X-ray crystallographic determinations. This fact has recently been a matter of some dispute (Yensen, A. I. M. & M. E., *Inst. Metals Div.*, 320-332; disc. 332-349; 1929).

The increasing importance of nitrided steels has led to further investigations of the iron-nitrogen system. Qualitative and quantitative measurements by Lehrer (*Zeitschr. f. Electrochem.*, **36**, 460-473; 1930) by means of magnetization-temperature curves have been used to construct the equilibrium diagram for the iron-nitrogen system. The results show that up to 11 per cent nitrogen there are four phases, in agreement with the X-ray determinations of Hägg (*Zeitsch. f. Physik. Chem.* **8**, 455-474; 1930) and Eisenhut and Kaupp (*Zeitschr. f. Electrochem.* **36**, 392-404; 1930). Köster (*Archiv. f. Eisenhüttenwesen* **3**, 637-648; 1930) has shown that nitrogen in α-iron remains in supersaturated solution even after slow cooling, requiring prolonged heating at low temperatures for complete separation, with a resultant increase in conductivity and increase in coercive force from 4 to 7 gauss. The segregation of nitrogen in the supersaturated solution is further accelerated by cold working (*Archiv f. Eisenhüttenwesen*, **3**, 649-658; 1930).

A number of alloys of iron and non-magnetic elements has been investigated. Pure electrolytic iron having a trace of phosphorus has been found to have better magnetic properties than commercial silicon steel. (*Gayler, Metallwirtschaft*, **9**, 677-679; 1930.) The iron-silicon system has been studied by Haughton and Becker, (*Iron and Steel Inst. Jl.*, **121**, 315-335; 1930) using metals of higher purity than heretofore. The existence of phases corresponding to the compounds FeSi, and Fe_3Si_2 have been confirmed, and in addition a phase which is probably the compound Fe_2Si_5. The addition of 14.5 per cent silicon lowers the Curie point of iron to 490 deg. cent. A magnetic transformation point occurring at 82 deg. cent. in the Fe_3Si_2 phase confirms the earlier work of Murakami (*Tohoku Imp. Univ. Sci. Rep.*, **10**, 79-92, 1921). Oya (*Tohoku Imp. Univ. Sci. Rep.* **19**, 235-245; 1930) has found that additions of vanadium to iron first raise the Curie point then depress it, so that it is room temperature for 35 per cent vanadium. The alloys of iron and chromium with approximately 18 per cent chromium have been found to have zero magnetostriction (Dean, *Rensselaer Polytech. Inst. Bull. No. 26,* Eng. and Sci. Series; 1930). Fischer (*Rensselaer Polytech. Inst. Bull. No. 28*, Eng. & Sci. Series; 1930) has found that this range of alloys has higher permeability and is less sensitive to quenching strains than other alloys of this group. This behavior has already been observed in permalloy (Buckley and McKeehan, **26**, 261-273; 1925) and is in accordance with McKeehan's theory of magnetostriction (*Phys. Rev.* **28**, 158-166; 1926). Kussmann, Scharnow, and Messkin (*Stahl u. Eisen*, **50**, 1194-1197; 1930) have found that additions of copper up to 0.7 per cent increase the resistance of iron to corrosion without impairing its magnetic and electrical properties. A general deterioration of these properties is obtained for higher copper concentrations.

The relation of magnetic properties to mechanical hardness has been investigated by Messkin (*Stahl u. Eisen*, **50**, 105-106; 1930) who has found that cold rolling increases the remanence and coercive force of carbon steel; and by Herbert (*Proc. Roy. Soc.*, **130**, 514-523; 1930) who has observed age hardening of steel and non-magnetic metals subjected to a changing magnetic field.

Sachse and Hasse have found that (*Zeitsch. f. Physik Chem.*, [A] **148**, 401-412; 1930) regular crystals of ferromagnetic ferric oxide, Fe_2O_3, are unstable at all temperatures, the susceptibility falling by 60 per cent in 4 years at room temperature. The fact that ferric oxide has 10^{-10} the conductivity of the ferromagnetic metals, leads Sachse (*Zeitsch. f. Phys. Chem.*, [B] **9**, 83-91; 1930) to conclude that free electrons cannot be concerned in its magnetic properties. The ferrites of magnesium, lead, copper, and nickel are also ferromagnetic at ordinary temperatures, cadmium ferrite being sometimes ferromagnetic and sometimes paramagnetic (Holgersson and Serres, *Comptes Rendus*, **191**, 35-37; 1930). In mixtures of Fe_2O_3, NiO, and C_0O, Veil (*Comptes Rendus*, **190**, 181-183; 1930) has found a higher coefficient of magnetization for the composition represented by $(Fe_2O_3)_2$ $NiOC_0O$.

A somewhat higher Curie point has been obtained for nickel by Jordan and Swanger (*Bur. Std. Jl. of Res.* **5**, 1291-1307; 1930) which is believed to be due to the greater purity of their nickel specimen. Sadron has found that (*Comptes Rendus*, **190**, 1339-1340; 1930) small additions of chromium to nickel, causes the saturation value at absolute zero to diminish linearly with chromium content, the Curie point for an alloy with 12 per cent Cr being absolute zero.

Widespread interest in the nickel-iron alloys coming under the collective name of permalloy is indicated by its numerous modifications to meet specific needs. Elmen has obtained very high initial permeability and resistivity in nickel-iron alloys by additions of molybdenum, chromium or tungsten (U. S. Pat. 1,757,178; *Jl. Frank. Inst.* **207**, 583-618; 1929). Stäblein (U. S. Pat. 1,760,326) has obtained high resistivity by additions of silicon. Bandur (U. S. Pat. 1,743,089) and Yensen (*Elec. Jl.* **27**, 214-218; 1930) report that with suitable heat treatment some nickel-iron alloys may be made to acquire sensibly constant permeability over a limited range of induction. Similarly, Smith and Garnett (U. S. Pat. 1,746,500) have obtained substantially constant permeability in nickel-iron alloys by additions of copper. Also, Gumlich, Steinhaus, Kussmann and Scharnow (*E. N. T.*, **7**, 231-235; 1930) report that high resistivity and small variation of permeability with magnetizing force are obtained in nickel-iron alloys by small additions of manganese.

Von Auwers, (*Wiss. Veroffentlich Siemens-Konzern* **9**, 262-293; 1930) has studied the effect of strain on the magnetic properties of permalloy. The results of numerous experiments indicate that the properties of permalloy cannot be accounted for on the basis of strain alone.

Methods of design and testing of permanent magnets have kept abreast with the improvements in magnetic properties. Elenbaas (*Physica,* **10**, 273-286; 1930) has derived a formula for calculating the field intensity in a toroid with an air-gap, based on the assumption that the demagnetization curve is an ellipse; this should prove useful in the design of permanent magnets. It is well known that the magnetization of a ferromagnetic material by a steady field is considerably increased by the superposition of an alternating field. Schrankow and Janowsky (*Zeitsch. f. tech. Physik* **11**, 429-432, 1930) apply this method of bringing permanent magnets to high inductions. An accurate method of testing bent permanent magnets has been described by Webb and Ford (*I. E. E. Jl.,* **68**, 773-778; 1930) whereby both B and H are measured by means of search coils and a ballistic galvanometer. The superior properties of cobalt-steel as permanent magnets have found application in the magnetic compass for aircraft, disturbances from stray magnetic fields being avoided by shielding with hipernik, a nickel-iron alloy of high permeability (J. R. Gier, *Elec. Jl.,* **27**, 114-115; 1930).

The need for accurate and constant substandards of frequency has stimulated further work on vacuum tube oscillators controlled by the resonant magnetostrictive vibrations of magnetic materials. This method of control requires the use of materials which have good magnetostrictive properties and small temperature coefficients of permeability and expansion. Vincent (*Proc. Phys. Soc.* **43**, 157-165; 1931) has extended the range of the magnetostriction oscillator of Pierce, (*Proc. Am. Acad. Sci.,* **63**, 1-47; 1928) to radio frequencies by using corronil, a nickel-copper-manganese alloy, and glowray, a nickel-iron-chromium alloy (*Proc. Phys. Soc.* **41**, 476-486; 1929); the latter, particularly, has a high degree of stability. Smith (*Proc. Phys. Soc.* **42**, 181-189; 1930) has determined the nature and magnitude of the coupling between the mechanical vibrator and the electric circuit for a toroidal specimen of a nickel-iron alloy vibrating radially in its fundamental mode. Muzzey (*Phys. Rev.* **36**, 935-947; 1930) has used the magnetostriction oscillator as a means of exciting cylinders of stainless steel in studying the dependency of frequency of vibration on length and diameter of the cylinders.

ACKNOWLEDGMENT

The Committee is indebted to Professor L. W. McKeehan, of its membership, and to Mr. P. P. Cioffi for material for this report.

General Power Applications

ANNUAL REPORT OF COMMITTEE ON GENERAL POWER APPLICATIONS*

THE principal activity of the Committee during the past year has been in arranging and carrying out of plans for the Industrial Session held at the Winter Convention. As this Committee is interested in the application of electricity to all industries which are not specifically covered by other committees of the Institute, it was agreed that papers to be of interest to the greatest number of engineers should be of a general nature and not confined to a specific industry or application. The papers presented were consequently arranged and prepared with this thought in mind. During this period of industrial depression an increasing amount of attention is being given to the subject of reducing manufacturing costs and it was hoped that industrial engineers would find in these papers various ideas which could be applied to their own problems.

INDUSTRIAL PAPERS PRESENTED

Besides those papers presented at the Winter Convention several other papers of an industrial nature were presented at district meetings. Following is a list of those papers which have come to our attention:

Philadelphia Meeting Oct. 13 to 15, 1930:

Air Conditioning in Industry, by A. H. Clogston of the Cooling and Air Conditioning Corp.

A New System of Speed Control—A-C. Motor-Driven Power Station Auxiliaries, by A. M. Rossman of Sargent and Lundy, Inc.

Louisville Meeting, Nov. 19 to 22, 1930:

Electricity in the Cement Industry, by R. H. Rogers of the General Electric Company.

Electric Power in the Lumber Industry, by A. H. Onstad of Weyerhaeuser Timber Co.

Winter Convention, January 26 to 30, 1931:

Electron Tubes in Industry, by W. R. King of General Electric Co.

Automatic Regulators in Industry, by J. H. Ashbaugh, Westinghouse Electric and Manufacturing Co.

Electrical Distribution Systems for Industrial Plants, by W. J. McClain, of Louis T. Klauder Co.

The Synchronous Motor with Phase-Connected Damper Winding as a Drive for High-Torque Loads, by M. A. Hyde, Jr., Westinghouse Electric and Manufacturing Co.

The Design and Application of Synchronous Motors to Meet Special Requirements, by D. W. McLenegan and A. G. Ferriss of General Electric Co.

Pittsburgh Meeting, March 11 to 13, 1931:

Conversion and Distribution of General Purpose D-C. Power in Large Industrial Plants, by R. D. Abbiss, Carnegie Steel Co. and D. C. West, Westinghouse Electric and Manufacturing Co.

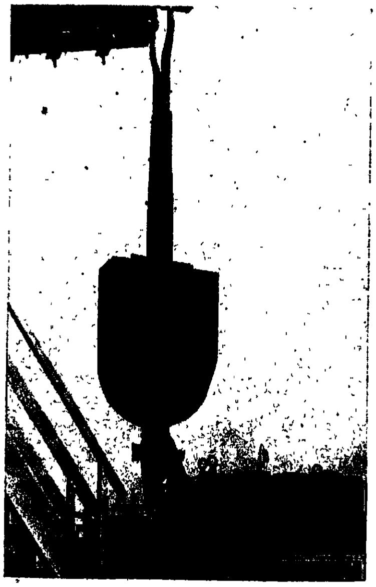


FIG. 1—COMBINATION PUMPING UNIT FOR OIL WELLS INCLUDING MOTOR, GEARS, AND CONTROL

Symposium on *Interconnection Between Utilities and Industries*. Several papers.

The Use of Electricity in Large Annealing Furnaces, by J. C. Woodson, Westinghouse Electric and Manufacturing Co.

A Modern Electrified Dairy Plant, by A. J. Dreux, Reick-McJunkin Dairy Co. and H. C. Brunner, Westinghouse Electric and Manufacturing Co.

REVIEW OF INDUSTRIAL PROGRESS

Since the past year has not been one of great industrial development or activity, it is felt that this report should include not only a review of the major industrial developments but also should indicate the trend of development along both application and apparatus lines in industry.

---

*COMMITTEE ON GENERAL POWER APPLICATIONS:

C. W. Drake, Chairman,
E. A. Armstrong,
James Clark, Jr.,
J. F. Gaskill,
Clyde D. Gray,
John Grotzinger,
Fraser Jeffrey,
A. M. MacCutcheon,
H. A. Maxfield,
John Morse,
N. L. Mortensen,
A. M. Perry,
D. M. Petty,
F. O. Prior,
H. W. Rogers,
L. D. Rowell,
M. R. Woodward.

Petroleum Industry

During the past year pipe-line transportation of liquid fuel over long distances has been extended to include gasoline. Electric pumping stations supplied with central station service, are increasing in number and proving their economy. The latest development is an electric station with three 800-hp. pumping units which is completely controlled from a dispatching office about 15 miles away. This is the Sand Springs Station of the Texas Empire Pipe Line that connects Oklahoma oil fields with the Chicago refineries. The supervisory control permits the dispatcher to exercise complete control over the station and gives a visual indication of its operation. The dispatcher can tell at a glance what units are operating, what the intake and discharge pressures are and as much other pertinent information as could be obtained if the operator were in the station. In case of trouble the equipment is shut down automatically and the dispatcher advised of the nature of the trouble.

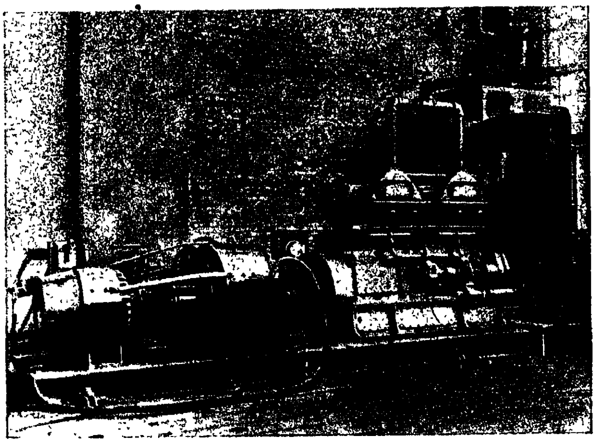


Fig. 2—Portable Diesel Engine-Driven Set for Variable Voltage Oil Well Drilling Outfits (Shop View)

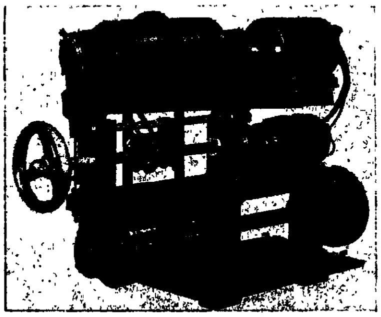


Fig. 3—Selsyn Generator and Cone Pulleys for Sectional Paper Machine Drive

Development in electrical oil field pumping and drilling equipment has been towards the use of combination, or factory assembled apparatus which eliminates many parts and reduces the installation expense in the field. One of the latest pumping units consists of a combination of gear, motor, and control built in one unit. The equipment is weatherproof and requires no housing. The unit is also provided with change gears for obtaining several speeds as required for various pumping conditions.

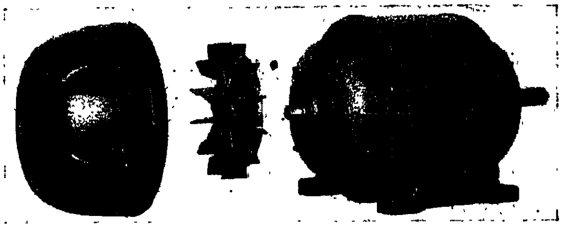


Fig. 4—Totally Enclosed Fan-Cooled Motor with Fan and Fan Casing Removed

During the past year several variable voltage d-c. oil well rotary drilling outfits have been built and put in service, using Diesel engines as prime movers. These outfits are being used primarily on locations where central station power is not available. The ease and simplicity of control obtainable with the variable voltage d-c. system, its low energy requirement and flexible operating characteristics, make this system very desirable for this type of oil service.

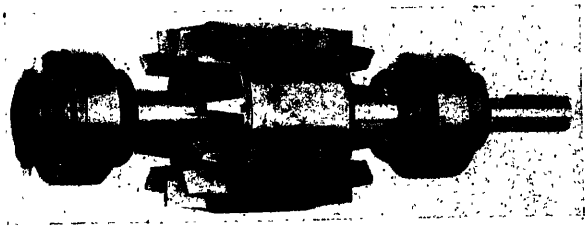


Fig. 5—Induction Motor Rotor Showing Cartridge Type Ball-Bearing Housings

Two installations are also reported where standard a-c. drilling equipments were installed and supplied with power from Diesel engine-driven generators, and, although this system may lack some of the desirable features of the variable voltage system, it makes it possible to use standard a-c. motors for pumping and other uses.

Pulp and Paper Industry

Sectional paper machine drives were installed during the year on a wide variety of machines from low-speed cylinder to high-speed fourdrinier and the use of section regulators of the carbon pile type instead of the contact making type was quite noticeable. A description of some of these carbon pile regulators is given in Mr. Ashbaugh's paper, presented at the Winter Convention.

A regulator for sectional drives using Selsyn equipment so that the main regulating equipment may be mounted remote from the paper machine has been placed in operation during the year. At the paper machine, in connection with each sectional motor, is a Selsyn generator driven through suitable cone pulleys which provide necessary speed adjustment or "draw" between the various sections. The resistance elements of the regulator are of the carbon pile type.

RURAL ELECTRIFICATION

The use of electricity on the farm has increased rapidly during the past year and reports from central stations indicate that approximately 90,000 farms were connected to their lines during the year. This represents an increase of 16 per cent over the total number previously connected. This growth is accounted for partly by the interest of the power companies in the farm load and partly by improved rate structures and power schedules. But of fully as great importance however is the increasing list of electrical equipment which is available and specially adapted for farm service. The attention being given to the production of milk with a low bacteria count has done much to force the installation of dairy sterilizing and dairy refrigerating equipment and these devices in connection with other dairy and household equipment make a very desirable electrical load.

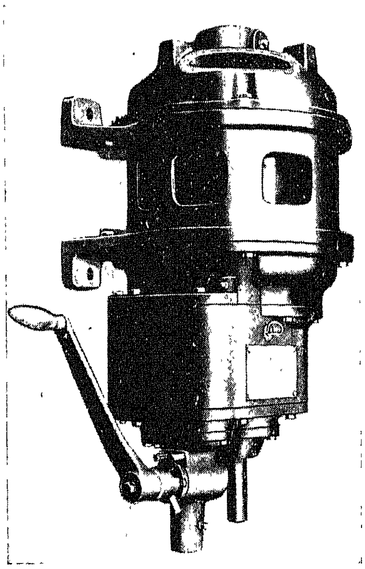


FIG. 6—MOTOR WITH BUILT-IN FOUR-SPEED TRANSMISSION SHOWING SPEED CHANGING LEVER

Engineering research and investigation have proven the possibility of using 5-hp. electric motors for practically all stationary work such as silo filling, feed grinding, wood sawing, etc., instead of using 15- or 20-hp. tractors. Numerous improvements have recently been made in the design and construction of portable motor equipment for such service which includes automatic linestarters with thermal overload protection, effective methods of belt tightening, and other desirable features.

FOOD PRODUCTS INDUSTRY

Although this industry has received but little attention from electrical engineers, it is the fourth greatest user of electric motors on the basis of connected horsepower. In addition to motors, electric energy is used for various other purposes as the production of ultraviolet rays to help preserve or increase the vitamin content of foods; photoelectric tubes for actuating operations of wrapping, sorting, and counting; cooking of foods by various electrical processes, and the pasteurization of milk.

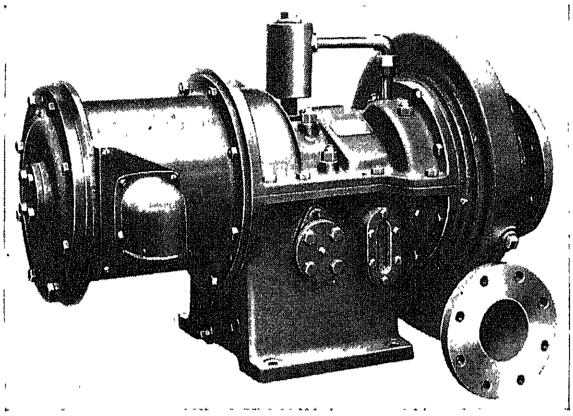


FIG. 7—GEARED CENTRIFUGAL REFRIGERATION COMPRESSOR DRIVEN BY TOTALLY-ENCLOSED INDUCTION MOTOR

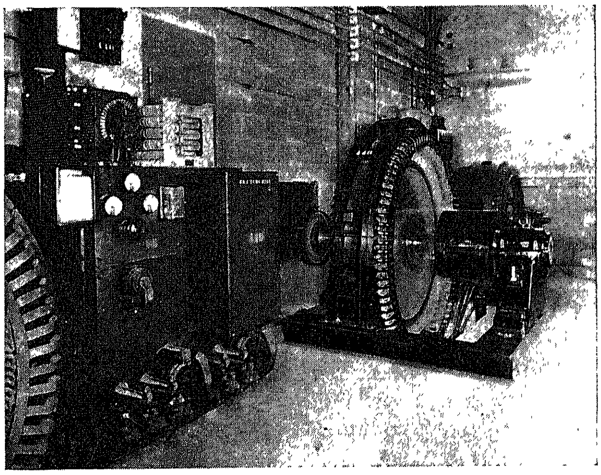


FIG. 8—300-HP. 164-REV. PER MIN. SYNCHRONOUS MOTOR OF THE PHASE-CONNECTED DAMPER TYPE AS INSTALLED IN A CEMENT PLANT

A paper on the subject of *A Modern Electrified Dairy Plant* was presented at the Pittsburgh District Meeting of the Institute March 11-13, 1931, by Mr. A. J. Dreux and Mr. H. C. Brunner. This paper illustrates how a modern electrified dairy offers a very desirable type of load for central stations, particularly when using the electrical conductivity method of pasteurization.

INDUCTION AND D-C. MOTORS

During the past year several new lines of induction motors have been placed on the market and the trend is toward simplification and standardization of design. The greater use of standardized parts reduces the stocks which must be carried both by the user and manufacturer, increases the number of combinations or types of motors possible with a given number of parts and in general makes the apparatus more universally adaptable.

Several new lines of totally enclosed fan-cooled squirrel-cage induction motors have been announced and in practically all cases these motors are on the same frame size as corresponding ratings of open motors. In these fan-cooled motors ball or roller bearings are used almost without exception and the cartridge type of bearing housing is quite generally adopted. This construction permits the dismantling of the motor and the removal of the rotor without exposing the bearings.

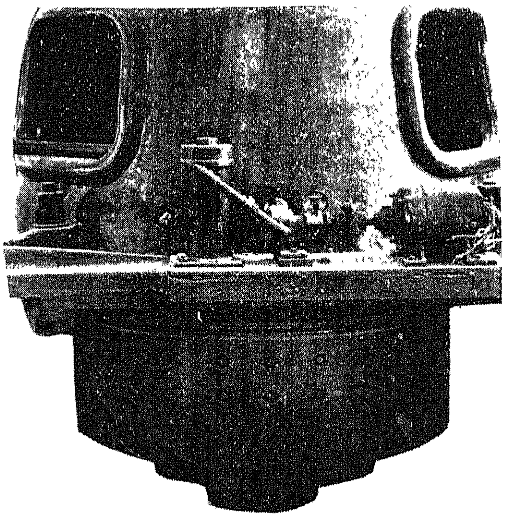


FIG. 9—SPECIAL SYNCHRONOUS MOTOR WITH EXTERNAL REVOLVING FIELD, DIRECT CONNECTED TO GYRATORY CRUSHER

A number of manufacturers has also brought out lines of totally enclosed fan-cooled motors for use in locations where explosive gases are present. These motors are approved by the Underwriters Laboratory for use in gasoline refining, garages, gasoline handling, and filling stations, dry cleaning establishments, chemical plants, paint factories, and in similar locations.

To meet the requirements of testing large vertical pumps and turbine wheels a vertical dynamometer rated at 300 hp. has been developed. The stator is supported in such a manner that it is free to rotate and the torque developed is measured on a beam and dial scale. The direct-current armature is especially constructed and makes use of a shrink-ring type commutator for high-speed operation.

Fractional horsepower motors of the universal commutator type have a wide speed range from no load to full load and consequently are not generally applicable for the constant speed service. A novel type of clutch has been developed which when installed in these fractional horsepower motors maintains a practically constant speed at the coupling regardless of how much higher the motor speed may go. This device consequently makes it possible to use universal motors for such applications as cash registers, calculating machines, small motor-generator sets, etc.

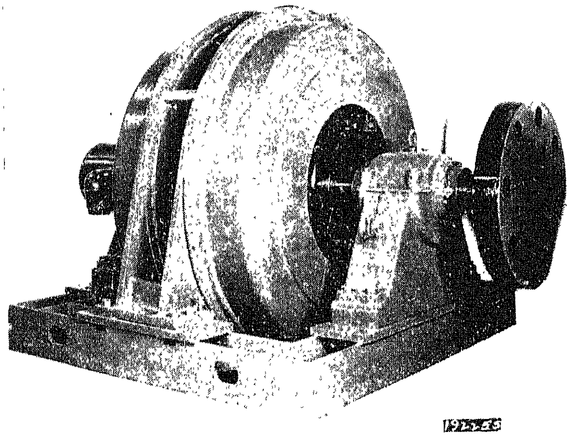


FIG. 10—250-HP., 450-REV. PER MIN. TOTALLY-ENCLOSED FAN-COOLED, SYNCHRONOUS MOTOR

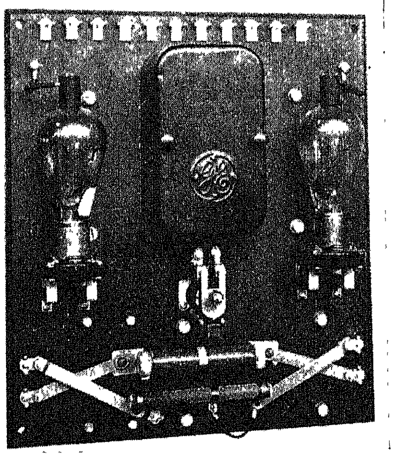


FIG. 11—ELECTRONIC TUBE CONTROL FOR SMALL D-C. MOTORS

Although speed reducers or gear reducers are now extensively used there is a decided trend towards the combination of various types of these gear reducers with industrial motors in order to form a more compact and self-contained unit. Some of these are of the fixed ratio type with either single, double, or triple reduction while others have a variable ratio. A recent addition consists of a standard constant speed motor in combination with a 4-speed gear forming a self-contained and very compact unit. With this combination various gear ratios are available and it is possible to change from one speed to another under full load conditions.

Another example of a combined unit is a centrifugal type compressor for refrigerating service in which the compressor, gears, and motor are combined in one unit. This is a high-speed single-stage compressor of approximately 25 tons refrigeration capacity and by means of the unit type construction it is possible to eliminate the usual shaft seals.

FIG. 12—SAMPLE CHART OBTAINED WITH SMOKE RECORDER

A paper presented by Mr. A. M. Rossman at the Philadelphia meeting *A New System of Speed Control for A-C. Motors*, gives a detailed account of a new method of speed control, its possibilities, and savings. The system consists essentially of a constant speed a-c. motor of either the synchronous or induction type, supplemented by an adjustable speed d-c. machine of much smaller size and a motor-generator set of similar capacity. The frame of the a-c. motor is mounted on bearings so that the frame as well as the rotor may rotate.

FIG. 13—CONSOLE TYPE BOARD FOR ELECTRONIC TUBE CONTROL OF THEATER LIGHTING AND DIMMING

SYNCHRONOUS MOTORS

At the Winter Convention two papers on the subject of synchronous motors were presented. The motor described by Mr. M. A. Hyde, Jr., was developed especially for low-speed applications requiring high starting and high pull-in torques with a low-current inrush. The damper construction instead of being of the usual squirrel-cage type is phase wound and in starting an external resistance is inserted in this circuit and the motor accelerates in a manner quite similar to that of the ordinary wound rotor induction motor.

The paper presented by Messrs. McLenegan and Ferriss discusses the design features of normal synchronous motors and shows how these features are varied to adapt synchronous motors to the requirements of various special applications. Among the various modifications discussed are the use of part-winding starting for applications where low-starting torques and low-starting inrush are desirable, also various methods of obtaining high-starting torque such as by means of over-sized motors, over-voltage, delta-Y starting, tapped windings, phase-connected damper windings for both salient and non-salient pole motors, and a rotable stator scheme.

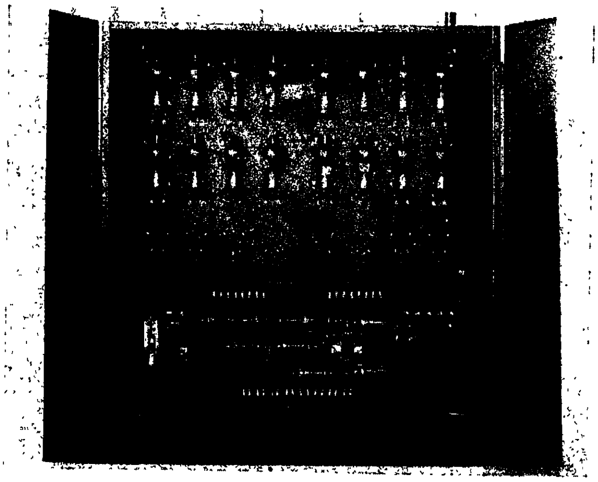


FIG. 14—ELECTRONIC TUBE CONTROL OF POLYCHROMATIC FLOOD-LIGHTING SYSTEM

It is reported that the first application of a synchronous motor directly connected to a grain elevator leg was made during 1930. Ordinarily the starting torque required by these legs or bucket elevators is comparatively light but in case of emergency such as starting after a power failure, with the buckets loaded, a high-starting torque and a high pull-in torque are required.

Although several high-torque synchronous motors have been applied to primary or large gyratory crushers most of these have been of the standard mechanical construction and usually belted to the crusher pulley. A unique application has been made which utilizes a vertical motor of the umbrella type in which the revolving field poles are external to the stator which in turn is bolted rigidly to the frame of the crusher.

Another interesting and rather unusual application of a synchronous motor is for driving a hot copper rolling mill which requires continuous reversing service. The motor is guaranteed to reverse in five seconds and a special type of damper winding construction is used to increase the radiating surface and dissipate heat caused by the frequent starting and stopping.

For use in the Chilean Nitrate Industry a number of synchronous motors rated at 250 hp., 450 r. p. m., was built of the totally enclosed fan-cooled type. This construction is necessary to protect the motors against the saline solutions and vapors and the construction details are along very much the same lines as carried out on the smaller industrial motors.

When protected type motors are required either on account of injurious vapors or dust, it is sometimes undesirable or impossible to locate the control equipment in separate rooms and to take care of those cases in which the control must be mounted in the same location as the motor, synchronous motor starters have been developed with the entire control immersed in a tank of oil.

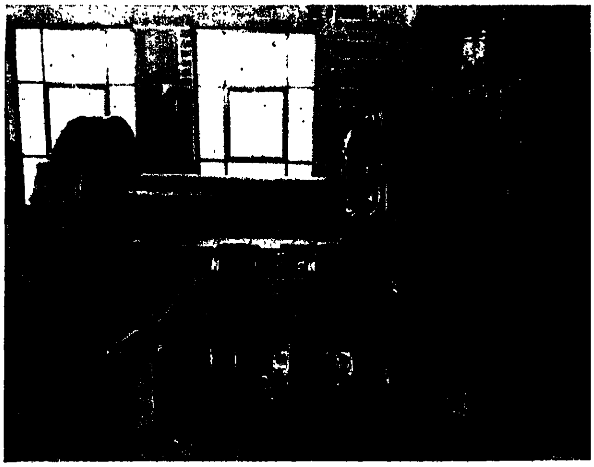


Fig. 15—Motor for Lower Elevator of Dual System with Combination Motor-Generator Set and Control Foreground

Electronic Tubes

During the past year the electronic tube has become an accepted industrial device. Its original use was confined to the arts of communication and science and not until recently has any concerted effort been made to apply it to industrial purposes. Electronic tubes possess characteristics not available in older forms of electrical apparatus but offer many possibilities for industrial applications. These characteristics may be listed briefly as follows: speed of operation, small actuating energy requirement, amplification properties, accurate response, quietness of operation, and freedom from moving parts and contacts. In addition, the actuation of electronic tubes may be brought about by a large number of different physical effects including changes in resistance, inductance, capacitance, phase angle, frequency, temperature, sound, light, color, radio or carrier current.

There has developed a demand for electronic tube units which can be adapted to many applications for experimental purposes. Such units have been brought out by several manufacturers. The more common of these are the photoelectric units and electrostatically controlled arc discharge units. The tubes used in the latter are better known by the trade names of grid glow or thyratron.

In line with this increasing interest a paper entitled *Electron Tubes in Industry,* was presented by Mr. W. R. King at the Winter Convention. This paper gives a general discussion of the theory and characteristics of electron tubes without going into design details or calculations. Several of the more common control schemes involving tubes are explained for the purpose of showing how tube characteristics can be adapted to various applications.

To eliminate the human element in determination of smoke density a device utilizing a light source and photoelectric tube in connection with a recording instrument has been developed and gives a continuous accurate record of smoke density. The light source is mounted on one side of the stack and throws a beam of light through an aperture on the photoelectric tube mounted on the opposite side. The amount of light reaching the photoelectric tube is determined by the smoke density, and indicating or recording instruments may be installed at any convenient location.

One of the most interesting and largest electron tube applications is the control of lighting for stages and auditoriums. Installations of this type involve the use of between 300 and 600 electron tubes. Three installations of this type are in the Civic Opera House in Chicago, the Severance Memorial Hall in Cleveland, and a theatre in Los Angeles. The latest of these units, the one at Cleveland, has all of the control circuits operated from an organ type console. With this control it is possible to pre-set scenes, gradually fade from scene to scene with either manual control or automatically at a pre-determined rate, and vary the intensity of any light circuit in the hall individually or in combination with any other circuit or circuits. In the old types of stage lighting control the intensity was varied by means of rheostats. This new method uses three-legged reactors located conveniently for load distribution and the degree of saturation and consequent change in light intensity is varied by rectified direct current from tubes. Another application for the same type of equipment as used for theatre dimming is the control of building flood lights. On a large number of new buildings the lighting is so arranged that the shading and colors vary in some regular cycle.

Electron tubes are also being used for speed control of d-c. motors in a number of various applications. At the present time for smaller motors, that is 3 hp. or below the control can be accomplished directly by control of armature voltage and current supplied from tubes, while for larger motors the field current only is controlled and supplied by tubes. One of the better known applications of this type is the maintaining of proper tension in the wire for a wire drawing machine and reel.

Photoelectric units have also been adapted to any number of production line applications where the objects are too light or fragile to operate ordinary control making or breaking devices by physical contact. On any application where an object can be made to intercept or otherwise vary a light beam this action can be used to actuate an operation. Some of the more common applications have been for counting, wrapping of packages such as foods, gum, etc., flag switches for reversing rolls as in steel mills, flashover protection of rotary converters, cutting of paper sheets to the proper length as required in connection with paper bag machines, paper break indicators in connection with paper machines, turning on and off lights in factories or offices to give proper illumination without wasting of power, and determining the transparency of paper.

ELEVATOR EQUIPMENT

During the past year numerous improvements and refinements in elevator electrical equipment were made in keeping with the tendency toward higher speeds, automatic landing control, and quieter operation. The common trend toward combination units is also illustrated in elevator apparatus by building of motor-generator sets with exciter and control in one frame.

One of the completely new and interesting developments of the past year was the building of an elevator with two cars operating in one shaftway. Obviously the object of this arrangement is the saving of floor space in tall buildings where the space occupied by elevator shaftways is both valuable and large, inasmuch as the shaftway area must be subtracted from each floor. This elevator embodies all of the latest features in elevator design including automatic floor landing, door opening, and futuristically decorated cars. The cars use the floor bottom system of control and in addition a set of signals are displayed in each car indicating the relative position of both cars in the shaftway. The cars are prevented from approaching each other closer than two floors by an automatic block system of control which brings the car to a normal stop when this limiting distance is reached.

CONCLUSION

The Committee feels that there is a large field open for the electrical engineer in industry and that the Institute can be of material assistance to its members by bringing before them the important developments and trends in the various industries. In the preparation of this report we desire to acknowledge the assistance given by the various members of the committee and also by the Electric Machinery Manufacturing Co.

Instruments and Measurements

ANNUAL REPORT OF COMMITTEE ON INSTRUMENTS AND MEASUREMENTS*

THE Committee on Instruments and Measurements has been active during the past year on the following subjects:

1. Standard definitions for telemetering.
2. Standards for recording instruments.
3. Standards for indicating instruments.
4. Revision of Standards No. 14—Instrument Transformers.
5. Revision of Electrical Units.
6. Symposium on precision measurements.
7. Technique of temperature measurements.
8. Measurement of reactive power.
9. Method of measuring distortion factor.
10. Review of proposed papers.
11. Conclusion.

STANDARD DEFINITIONS FOR TELEMETERING

The subcommittee devoted to telemetering has been active for a number of years. Last year in this report there were published for comment standard definitions on this relatively new subject. It has been felt that, with the interest in the field of telemetering, it would be desirable to have some standard definitions so that the terms which are used would not be results from a hit and miss selection, as often occurs in newly developed fields. With comments received this year a set of standard definitions was approved by the membership of the Instruments and Measurements Committee, and is now ready for transmittal to the Standards Committee for adoption.

STANDARDS FOR RECORDING INSTRUMENTS

As a result of several years work, a subcommittee has completed a draft of proposed standards for recording instruments. These standards have been approved by the Instruments and Measurements Committee, and are now ready for submission to the Standards Committee.

The work of the subcommittee is under the chairmanship of Mr. Kinnard. A large amount of work has been involved in the development of these standards so as to cover this field of measuring instruments. The Committee has considered many new items which have shown that the Standards for Indicating Instruments should also be revised.

STANDARDS FOR INDICATING INSTRUMENTS

Since 1927, Instrument Standards No. 23 has been used by the industry. Since that time considerable progress has been made, and experience with the Standards has indicated that a revision would be desirable. A subcommittee was appointed at the beginning of this year to start the revision.

REVISION OF STANDARDS NO. 14—INSTRUMENT TRANSFORMERS

A subcommittee has been active during the past year revising Standards No. 14 covering instrument transformers. This standard was approved in 1925. It was the feeling of the members of the Instruments and Measurements Committee that progress in the art warranted revision at this time. The committee is under the chairmanship of Mr. Gibbs. Several tentative drafts have been prepared and revised so that these standards will soon be in form to be submitted to the Committee membership for approval.

REVISION OF ELECTRICAL UNITS

The report of the Committee on Instruments and Measurements for the Institute year ending July 31, 1929, contained a brief account of the participation of this Committee in the events which led up to the first meeting of the (international) Advisory Committee on Electricity at Paris in 1928. At that meeting resolutions of far-reaching importance were adopted, to the effect that the absolute system of electrical units, derived from the c. g. s. system, may be substituted with advantage for the present international system of units which is based upon arbitrary legalized material standards, namely, the mercury ohm and the silver voltameter.

The second meeting of the Advisory Committee on Electricity was held in Paris in June 1930. The American representative on the Committee, Dr. G. K. Burgess, Director of the Bureau of Standards, was prevented from attending, and sent Dr. H. B. Brooks as his substitute.

Representatives were sent by the national standardizing laboratories of England, Germany, Japan, and the Soviet Republics; by the Laboratoire Central d'Electricite of Paris, and the International Bureau of Weights and Measures at Sevres. Italy was represented by Professor L. Lombardi of the Royal School of Engineers at Rome. Other experts were present as invited guests. A large part of the sessions was taken up with the discussion of a new duty which the International Committee of Weights and Measures had recently laid upon the Advisory Committee on Electricity, namely, that of advising the International Committee on all questions relating to the methods of measurement and to the units and standards of light.

---

*COMMITTEE ON INSTRUMENTS AND MEASUREMENTS:

E. J. Rutan, Chairman,
H. S. Baker,
P. A. Borden,
H. B. Brooks,
O. J. Bushnell,
A. L. Cook,
E. D. Doyle,
Melville Eastham,
M. Eppley,
R. C. Fryer,
J. B. Gibbs,
W. N. Goodwin, Jr.,
I. F. Kinnard,
O. A. Knopp,
A. E. Knowlton,
H. C. Koenig,
W. B. Kouwenhoven,
F. A. Laws,
E. S. Lee,
Paul MacGahan,
R. T. Pierce,
W. J. Shackelton.

Concerning the primary standard of light, resolutions were adopted supporting the view that a black-body radiator should be adopted; requesting the national laboratories to examine the specifications for the Waidner-Burgess primary standard of light and to give their views regarding the practicability of its adoption; and urging the desirability of making additional determinations of the brightness of the black-body radiator, especially under the conditions prescribed by the Bureau of Standards' specifications, or at least under conditions comparable with them.

Concerning the unit of light and its maintenance, the Advisory Committee adopted a resolution to the effect that it is inexpedient to change the unit (*i. e.*, the international candle) which has been in use since 1909. Other resolutions adopted relate to the exchange and comparison of groups of lamps by the national standardizing laboratories, and to the adjustment of the values of the practical secondary standards, as may be necessary in the future as a result of reference to a primary standard.

Concerning the electrical units and standards, two resolutions were adopted, as follows:

1. With regard to the unit of resistance, the ohm, considering that methods of determining the absolute ohm are sufficiently advanced and that the agreement between the measurements of the coils (secondary standards) of the different laboratories remains within the limits of precision of the measurements, it is not necessary at present to undertake further comparisons of the resistance coils with mercury ohms.

2. As to the units of electromotive force, on the contrary, the international comparisons of standard cells show differences, exceeding the limits of possible precision, between the values of the electromotive force of the standards of different countries. The committee considers that it is absolutely necessary to make new determinations of the electromotive force of the international Weston cells in each national laboratory by means of the silver voltameter.

The conditions under which the silver voltameter should be used are specified sufficiently in the report of the international committee which met in Washington in 1910. The Advisory Committee recommends, however, that the national laboratories use the Smith or the Kohlrausch voltameter, avoiding organic material, which is detrimental to the electrolytic deposit.

The groups of Weston cells prepared in the several laboratories can be considered as sufficiently constant until the absolute unit of current shall be established.

It should be noted that these recommendations concerning standard cells and voltameters do not in any way modify the Advisory Committee's recommendation of 1928 looking to the ultimate legalization of the absolute ohm, volt, and ampere on a basis free from all arbitrary character. The recommendations merely recognize that the standard cell and the silver voltameter are useful tools, when properly used, and are essential to the maintenance and dissemination of the international electrical units under the existing limitations.

The Advisory Committee also made recommendations regarding the equipment of the International Bureau of Weights and Measures and plans for cooperation between that bureau and the national laboratories in work on electric and photometric standards. Since an international General Conference on Weights and Measures is to be held in 1933, the Advisory Committee decided that it should meet again before that time to study the comparisons of standards which shall have been made and to assign values in absolute units for the standards of resistance and of electromotive force.

SYMPOSIUM OF PRECISION MEASUREMENTS

In view of the recent activity of the International Advisory Committee on Electricity, it was felt desirable to have some outstanding papers written concerning the fundamental electrical units. The subject is being treated in a symposium which is being presented at the 1931 Summer Convention and which includes four papers. These are:

1. *International Standard of Electromotive Force and Its Low-Temperature Coefficient Form*, by Marion Eppley, the Eppley Laboratory, Inc.
2. *The Unit of Electrical Resistance; Past History and Impending Change*, by H. B. Brooks, National Bureau of Standards.
3. *Design of Potentiometers*, by I. Melville Stein, Leeds and Northrup Company.
4. *Electrical Units and Their Application*, by L. T. Robinson, General Electric Company.

TECHNIQUE OF TEMPERATURE MEASUREMENTS

In order to set up a standard code for temperature measurements, a subcommittee has been appointed. This committee has already analyzed all of the temperature requirements included in the various standards of the Institute, and is now summarizing these data preparatory to setting up the necessary measurement technique.

MEASUREMENT OF REACTIVE POWER

Considerable interest is being displayed in the matter of measurement of reactive power. A subcommittee has been considering this subject, and is cooperating with a committee appointed by the

Standards Committee under the chairmanship of Mr. A. E. Knowlton.

METHOD OF MEASURING DISTORTION FACTOR

In line with the recommendation of this Committee, made in last year's annual report, a subcommittee has been following the performance of Belfils Bridge which is being used by one of the manufacturing companies. The work has progressed to the point where a report has been prepared covering the performance of this apparatus. At the present time the report is in circulation among the members of the Instruments and Measurements Committee in order that their comments and recommendations may be obtained in regard to the suitability of this device for the measurement of distortion factor.

PAPERS

In addition to the four papers mentioned above in connection with the symposium of precision measurements, nine papers have been submitted to this Committee for review. Some of these have already been approved for publication and presentation and the remainder are in circulation and will be reported on shortly. These papers are listed below:

Measurements of Cable Insulation Characteristics

A High-Sensitive Power-Factor Bridge, by W. B. Kouwenhoven and A. Banos.

High-Voltage Bridge for Measurement of Cables with Grounded Sheaths, by C. F. Dawes and A. F. Daniel.

The Elimination of an Inherent Error in the Usual Form of Capacitance Bridge for Capacitance and Power-Factor Measurements by the Substitution Method, by R. P. Siskind.

Measurements of Magnetic Flux

Core Loss Measurements at High-Flux Densities, by B. M. Smith and C. Concordia.

This paper was presented at the Northeastern District Meeting, Rochester, N. Y., April 1931.

Miscellaneous Subjects

A Direct-Current Bushing Transformer, by A. S. Fitzgerald.

A New Overcurrent Relay with Straight Line Characteristics, by S. L. Goldsborough and R. M. Smith.

A Thermionic Type Automatic Synchronizer, by F. H. Gulliksen.

The Characteristics of the Oscillograph-Galvanometer, by V. S. Thomander.

The Amplifier-Oscillograph, by S. K. Waldorf.

CONCLUSION

Active interest has been shown by the members of the Committee on Instruments and Measurements through the year. The meetings held were well attended and subcommittee reports indicated considerable progress was being made in each of the assigned activities, and definite steps have been taken on several as indicated above. During the coming year it is expected to complete some of the other projects.

Applications to Iron and Steel Production

ANNUAL REPORT OF THE COMMITTEE ON APPLICATIONS TO IRON AND STEEL PRODUCTION*

THE functions of this committee have, in the past, been largely confined to (1) encouraging the presentation of papers before the Institute dealing with those phases of electrical engineering which are major factors in the utilization of electricity in the steel industry. (2) To preparing an annual report which briefly summarizes such phases of the application of electricity to the production of iron and steel as are considered new or of special interest to the membership.

During the past year, the committee's work has followed the previous precedent, in procuring papers. It also actively cooperated in arranging a joint session of the Institute with the Association of Iron and Steel Electrical Engineers at the meeting of the Middle Eastern District held in Pittsburgh on March 11th to 13th inclusive, 1931. The papers presented before this meeting which the members of this committee were active in procuring are as follows:

1. "Conversion and Distribution of General Purpose D-C. Power in Large Industrial Plants," by R. D. Abbiss, Carnegie Steel Co., and D. C. West, Westinghouse Elec. & Mfg. Co.
2. Symposium on Interconnection Between Utilities and Industries: Davison Coke and Iron Co. and Duquesne Light Co. Interconnection, by G. E. Dignan, Davison Coal and Iron Co. and R. L. Kirk, Duquesne Light Co.
3. "Interconnection of Power Supply Between Public Utilities and Large Industrial Users," by F. O. Schnure, Bethlehem Steel Co.
4. "Absorption of By-Product Power," by A. Hoeffle, Toledo Edison Co. and W. T. Woodmancy, Interlake Iron Corp.
5. "The Use of Electricity in Large Annealing Furnaces," by J. C. Woodson, Westinghouse Elec. & Mfg. Co.

The Committee wishes to report that this joint meeting of the Institute and the Association of Iron and Steel Electrical Engineers was a very successful part of the Middle Eastern District Meeting Program, and suggests that joint meetings with the Association of Iron and Steel Electrical Engineers be encouraged in the future.

ELECTRICAL DEVELOPMENTS IN THE IRON AND STEEL INDUSTRY DURING 1930

During the year 1930 there has been a general recession from the unusually high operating rates of the preceding year, and an accompanying reduction in expenditure for improvements and new plant facilities. However, an impressive amount of electrical equipment has been purchased and many interesting developments have taken place. Undoubtedly, the very successful electrification of rolling mills and their auxiliaries has been an important factor in the steel industry.

The iron and steel industry during 1930, purchased 163,490 total horsepower of main drive motors, rated 300 hp. or over, as compared to a total of approximately 350,000 hp. during 1929. The fact that the rate of increase in installed horsepower for main drives is greater than the rate of increase for ingot capacity, indicates the tendency to modernize old mills.

Direct Current Motors

Many important installations have been completed during 1930, with others rapidly nearing completion. From various viewpoints, a new 10,000-hp., 54-inch blooming mill in the Chicago District is memorable. It is the most powerful mill yet installed by a margin of 2,000 hp., an increase in power which will be useful in rolling thicker and heavier sections. This tends toward greater output of the whole plant, the blooming mill being the first of all the rolling operations.

Even more than for its size, this mill is unique in that the two main rolls, usually geared together, are driven individually, each by its own motor. This is a great improvement over the former method of a single motor coupled to a pinion stand. The ordinary construction of mill pinions and housings permits wear and misalinement from which develop accelerated wear, noise, vibration, and occasional breakage. Often the mill must continue in operation for several days after trouble has been developed before it can be conveniently shut down.

Each roll of the new 54-inch mill is driven by a double armature motor rated at 5,000 hp., 700 volts, direct current, at 40/80 r. p. m., both motors being under electrical control which keeps the speed of the two rolls precisely the same. The torque developed is 4,000,000 lb-ft., from standstill up to normal speed. The motors are of minimum diameter to avoid angularity of the mill spindles between motor and rolls, an incidental advantage being smaller inertia.

---

*COMMITTEE ON APPLICATIONS TO IRON AND STEEL PRODUCTION:

A. C. Cummins, Chairman,
F. B. Crosby,
M. M. Fowler,
S. L. Henderson,
A. M. MacCutcheon,
A. G. Pierce,
F. O. Schnure,
W. B. Shirk,
G. E. Stoltz,
Wilfred Sykes,
T. S. Towle,
H. A. Winne.

Immediately following the 54-inch blooming mill just referred to is the 52-inch beam mill. The roughing mill is driven by a 7,000-hp. reversing motor, and a 2,000-hp. reversing motor for the edging stand. Likewise the intermediate mill will be equipped with reversing motors rated at 6,000 hp. and 2,000 hp.

There is now under construction by this same company, a 44-inch universal slabbing mill, the driving motors of which will have a continuous capacity of 12,500 hp., and a maximum emergency capacity of 35,000 hp. The upper and lower horizontal rolls are to be individually driven by two 5,000-hp., 40/80-r. p. m. reversing motors, constituting a twin motor drive of 10,000 hp., 4,000,000 lb-ft. maximum torque capacity, duplicate of the 54-inch blooming mill now in operation. The vertical edging rolls are to be driven by a third reversing motor, rated 2,500 hp., 79/225 r. p. m., 500,000 lb-ft. maximum torque capacity. Power for the three reversing motors will be furnished by a 10,500-kw. flywheel motor-generator set consisting of a 180,000-lb. flywheel, a 6,500-hp., 25-cycle, 6,600-volt, 370-r. p. m. induction motor, and three 3,500-kw., 700-volt generators connected in parallel. This installation will be of unusual interest to steel mill engineers because of the large size of the mill and the electrical equipment, and also because of the method of drive, utilizing three reversing motors with control to provide adjustment of relative speeds, thus permitting variations in drafting and the use of rolls of unequal diameter.

To secure the necessary refinement for the accurate automatic control of the screwdown mechanisms on a 32-inch three-high universal plate mill and on roughing and intermediate 52-inch universal structural mills, seven variable-voltage screwdown equipments have been installed. The variable-voltage control permits much more accurate settings than could be obtained with rheostatic control, either automatic or manually operated, and thus speeds up the operation of the entire mill. A further advantage is the elimination of the large capacity reversing and accelerating contacts and starting resistor, with accompanying lowered maintenance.

In addition to the 54-inch and 44-inch mills referred to above, this company is also completing a 96-inch continuous plate mill, a 10-inch alloy bar mill, a large open-hearth department, and a 20,000-kw. addition to the existing steam turbine power station.

The 10-inch alloy bar mill will be driven by nine direct current motors, totaling 7,627 hp. Some of the motors have a speed range of approximately 5 to 1, which is obtained partly by motor field adjustments and partly by armature voltage control through the use of auxiliary bucking generators, one for each of two motors which have this large speed range. The use of these bucking generators permits operating the three main 1,750-kw., 600-volt generators in parallel at constant bus voltage. The motors will be equipped throughout with speed regulators of the vibrating type, designed to hold the speed regulation within very close limits.

An 8,000-hp., 40/100-r. p. m. reversing motor is now being built to drive a 44-inch blooming mill at Gary. This motor will be capable of developing a maximum torque of 2,900,000 lb-ft. The mechanical parts of this motor, including the armature spider, will be of fabricated steel construction throughout. Several reversing motors with fabricated and electrically welded armature spiders have been in service for some time, demonstrating beyond doubt the reliability of this type of construction. Power for the 8,000-hp. motor will be supplied by a 375-r. p. m. motor-generator set, consisting of two 3,500-kw. generators, one 6,000-hp., 6,600-volt, 25-cycle induction motor, and one 200,000-hp-sec. flywheel.

A southern steel company has placed in operation at Alabama City, a new 40-inch blooming mill which replaces an engine-driven 36-inch mill. The 40-inch mill is driven by a 7,000-hp., 700-volt, 50/120-r. p. m., single-armature reversing motor supplied with power from a 6,000-kw. flywheel motor-generator set. This company has also installed a new 32-inch three-high universal plate mill driven by a 4,000-hp., 80/160-r. p. m., d-c. motor, similar to a reversing mill motor, with variable-voltage power supplied by a 3,200-kw. flywheel motor-generator. The major part of the mill output is light gage sheets. The type of drive used permits the operator conveniently to select low speeds for the roughing passes, and high speeds for the finishing passes, with very rapid acceleration to the desired rolling speeds. An important feature of this mill is the automatic screwdown. When the operator moves the pass master switch to each successive position, the desired screwdown setting for each pass is obtained by automatic control.

A 20-inch continuous hot strip mill in the Detroit District was put into operation in 1930. This mill has ten stands, each driven by an individual d-c motor. The drive for this mill has one very interesting feature. When rolling from slabs of such length that the piece will reach from stand 4 to stand 5, the section of the bus to which the first four motors and one 5,000-kw. generator set are connected, is segregated from the bus to which the remainder of the motors and the other generators are connected. This is necessary because the minimum speeds of the first four motors when operating at normal rated voltage are such that the metal would be delivered from stand 4 at a very much higher speed than it enters stand 5. Consequently, when the piece is continuous between stands 4 and 5, the speeds of the first four stands must be lowered by reducing the voltage of the generators on the section of bus to which the first four motors are connected. A similar arrangement was incorporated in the control of the first two motors on the 60-inch strip mill in a plant at Steubenville, Ohio.

Motor drive has for the first time been successfully applied on a large scale to the operation of a 900-ton ingot pressing application that was formerly monopolized almost entirely by steam or hydraulic operation. This press is in the new plant of a wrought iron manufacturer near the Pittsburgh District and compresses wrought iron sponge balls, about five feet in diameter, into rectangular ingots, measuring about 6 ft. by 18 inches square, preparatory to rolling in the blooming mill. On the final squeeze, it is necessary to exert a pressure of at least 1,000 pounds per square inch. Maintenance of factory production at full speed, requires operating the rams up to 75 feet per minute. Still the motors and press must be protected from the enormous stress which would result if the ram was brought up suddenly against a solidly compressed ingot. The solution of these and other problems involved a coordination of generator, exciter, and motor characteristics with manual and automatic control facilities, so that, as the pressure increases, the ram speed is slowed up towards the end of its stroke and the current will never exceed the allowable limit.

The main 900-ton ram is driven, through four racks and eight pinions, by a double-armature, 1,200-hp., d-c. reversing motor, having a normal full-load speed of about 125 r. p. m., and a maximum light-load speed of 275 r. p. m. The motor was built with two armatures in order to reduce the $W R^2$ and to halve the current to be carried by each commutator. The auxiliary 200-ton end rams are driven by a 325-hp. single-armature motor, having a nominal full-load speed of 250 r. p. m. and a maximum light-load speed of 550 r. p. m. The motors are of sturdy mechanical construction, with cast steel armature spiders, special armature coil bracing, and thrust bearings at the coupling end. Rear enclosing end bells are provided so that the motors may be ventilated. This is necessary as the motors carry heavy loads at very low speeds, and are therefore incapable of self-ventilation.

Variable-voltage d-c. power for the two press motors is furnished by a four-unit synchronous motor-generator set, consisting of a 1,000-kw. generator for the large motor, a 300-kw. generator for the small motor, a 1,500-hp., 80 per cent power factor, 6,600-volt, three-phase, 60-cycle, synchronous driving motor, and a 50-kw., 250-volt exciter.

In addition to the electrical features enumerated, the mechanical design of the press incorporates a number of features intended to provide safe and reliable operation. The faces of the main ram head and stationary side stop are not smooth but have corrugations vertically and horizontally across them, so that on the first impact, only about 10 per cent of the total face of the ram strikes the ingot and the ram has to move in about 1½ inches before the entire face strikes.

The electrically driven press has been in operation several months, and its success has demonstrated the practicability of electrical drive for such machines.

A mill in the Youngstown District has purchased the electrical equipment for a 10-inch bar mill having 12 tandem stands. Ten d-c. motors totaling 7,350 hp. with variable-voltage control from two 2,000-kw. motor-generator sets will be used with this mill. The mill will have two unique features, one being the method of speed control and the other is the use of vertical motors to drive the vertical roll main stands.

A speed regulator of the carbon pile type is used with each motor and with a master frequency generator to maintain a desired speed relation between stands. The customary bevel gear drive to the rolls has been eliminated by the use of vertical motors. The vertical motor is mounted above the mill on an overhung support. This support also carries the rolls and pinion housing. The rolls can be moved sideways or up and down with respect to the bar being rolled so that the vertical rolls can be lined up with the grooves of the horizontal rolls.

Synchronous Motors

Among the more important synchronous motors which have been purchased during the year may be mentioned two 4,500-hp., 156.5-r. p. m., 6,600-volt, 60-cycle units which will drive two rolling mills in the plant of a Pennsylvania manufacturer. This company also purchased one 5,000-hp., 360-r. p. m., 6,600-volt synchronous motor to drive a 24-inch billet mill and one 4,000-hp., 360-r. p. m., 6,600-volt motor to drive a 28-inch billet mill at the same plant early this year. This company put into operation a 3,000-hp., 100-r. p. m., 11,000-volt, three-phase, 60-cycle synchronous motor, driving a three-high billet mill. This motor is of interest not only because it is one of the few main roll motors operating at over 6,600 volts, but also because it is started directly from the 11,000-volt circuit.

A West Virginia manufacturer has purchased two synchronous motors, one 2,000-hp., 800-r. p. m. and one 1,000-hp., 360-r. p. m., which will drive the hot tin mills. This is believed to be the first installation of synchronous motors on mills of this character, previous practise having been to use induction motors with flywheels. Synchronous motors were chosen because of the necessity of maintaining a good power factor, and also because of the gain in efficiency. Not only is the synchronous motor itself more efficient than the corresponding induction motor, but the friction and windage losses of the usual flywheel and the power losses in the secondary resistor or liquid slip regulator are eliminated. It is estimated that the power per ton of tin plate rolled will be at least 5 to 10 per cent less than if an induction motor flywheel drive had been used.

Switchgear

All the modern improvements in switchgear equipment are rapidly being adopted by the iron and steel industry. The metal clad type of switchgear with its live parts completely enclosed, excluding dust and dirt and at the same time protecting the operator from possible injury, is ideally suited to steel mill service.

Auxiliaries

Automatic screwdown equipment has been developed to the point where it will rapidly become more generally used. Two recent applications, one in a universal plate mill and the other in a structural mill have been mentioned in this article. The use of variable-voltage equipment for these screwdown drives has proved very desirable.

There is increasing industrial activity in the application of vacuum tubes and related devices. The crane operator on the soaking pit cranes for a 54-inch mill in the Chicago District will control the opening and closing of the soaking pit covers through the action of photoelectric cells. In another plant, a photoelectric cell acts as a "flag" switch to make the necessary set-up for registering the temperature of each billet as it approaches the rail mill. Undoubtedly, the field for such applications will rapidly increase.

The majority of the motor-driven heavy shears, such as bloom and slab shears, which are now in operation, are driven through clutches by induction motors equipped with flywheels. The mechanical clutches are a source of more or less trouble, and to eliminate these and also the losses in the continuously running motor and flywheel, several shears have recently been installed with d-c. motor drives, arranged to start and stop with each cut.

Two of these are in a new plant near Detroit. The larger of the two is an 800-ton slab shear, designed to cut a slab 8 inches thick by 25 inches wide. Another midwestern steel plant has recently placed in operation eight shears, cutting cold stock up to a maximum of ¼ inch thick by 42 inches wide. Some idea of the high rate of acceleration and retardation may be obtained from the fact that the shear makes a complete cycle in less than one second, and during this time the motor starts from rest, attains a speed of over 450 r. p. m., cuts the plate and stops.

A Pittsburgh tube mill has installed two scrap shears for crushing and shearing pipe up to 24 inches. They are of the new type with the shear motors starting and stopping for each cycle.

What is believed to be the first application of synchronous motors to flying shear drive is in connection with a 20-inch hot strip mill in the Detroit District. The shear is of the rotary flying type, and, to insure that the metal shall be cut into equal lengths, it is necessary that the speed of shear be synchronized with the delivery speed of the metal from the mill. To accomplish this, an a-c. generator is provided on each stand, from which the metal may be delivered. The shear is driven by a synchronous motor, the power for which may be obtained from any of the a-c. generators.

Three ore unloaders recently placed in operation at one of the Lake Erie Docks are interesting on account of their large size. The combined capacity of the three unloaders is 3,600 tons per hour, and the actual time for unloading a 10,000-ton boat is four or five hours. The bucket capacity for each unloader is 17 tons. Each unloader uses eight motors totaling 1,060 hp. The beam hoist motor is a 350-hp., 500-r. p. m., shunt-wound mill motor and the trolley travel motor is a 170-hp. motor, these two motors having variable voltage control. The bucket closing and opening motor is a two-speed wound-rotor mill type motor, and all other motors are a-c. motors. The motor-generator set for the variable-voltage control is mounted inside the beam and serves to help balance the stiff-leg weight.

As electrical improvements in the iron and steel industry are reviewed each year, the opportunities that exist for improvements in steel mill drives and auxiliary equipment become increasingly evident. These improvements will result from a close cooperation between the steel plant engineer, the mill builders, and the engineers of the electrical manufacturer.

Production and Application of Light

ANNUAL REPORT OF THE COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT*

PRODUCTION OF LIGHT

Statistics on Incandescent Lamp Sales

THE sale of incandescent lamps held up remarkably well during the past year, large lamps showing a decrease of about 1 per cent as compared with 1929. The Central Station revenue derived from the two classes of service in which light is a large factor (domestic and commercial, small power and light) showed an increase of about 7.5 per cent as compared with the previous year, offsetting the reduction from other uses of electricity, and leaving a net increase of about 3 per cent.

The average lumens, watts, and efficiency of the large lamps sold last year all increased as compared with the year before. The average lumens went from 797 to 814; the average watts from 60.7 to 61.2 and the average lumens per watt 13.1 to 13.3.

Of the sixteen standard wattages from 10 to 1,000 inclusive, used in multiple service, three sizes 60, 100, and 200 watts, represent nearly half (46.6 per cent) of the total wattage demand.

The percentage of 110-volt and 115-volt lamps sold decreased slightly, while that of 120-volt gained as compared with the previous year. The percentage distribution for last year for 110-, 115-, and 120-volt lamps was 5.2 per cent, 48.9 per cent, and 41.3 per cent respectively. Lamps for 200-250-volt service decreased from 3.3 per cent to 2.6 per cent of the total quantity sold for multiple service.

The demand for street series lamps is concentrating on the 6.6 ampere rating. This now represents 71.2 per cent of the total; the next largest demand being 14.6 per cent which is for the 15- and 20-ampere compensator type lamps.

New Sources of Ultraviolet Radiation

A new type of lamp (called a glow lamp) has been developed which produces ultraviolet light by virtue of a glow discharge through mercury vapor between two hot cathodes of the oxide coated type. The two heater filaments for the cathodes are connected in series and their resistance produces a sufficient difference in potential to cause a discharge between the two cathodes, once they have become heated. The lamp is rated at 2 amperes and 18 volts. This lamp, designed for operation on alternating current requires a starting potential of some 35 volts, after which 18 volts is sufficient to maintain the discharge. One, two or three lamps may be operated on the ordinary 115-volt lighting circuit in connection with a suitable current-limiting resistance, reactance, or transformer. The glass bulb has been selected for its transmission characteristics so that the lamp will produce practically no radiation below 2,800 Angstrom units. In addition to producing the desirable radiations of ultraviolet light, it also produces blue and green light in the visible spectrum which may possibly be used to advantage in the future to supplement the light of Mazda lamps, to secure a nearer approach to a light subjectively white in color as well as to obtain the healthful ultraviolet radiation.

In last years report a new tungsten-mercury arc lamp was referred to. This lamp consumed about 315 watts. A lamp of the same general characteristics, but of about forty per cent of this wattage has recently been announced. The bulb is smaller, and is fitted with a metal cap which raises the operating temperature and pressure of mercury vapor in the bulb, and increases the efficiency of production of ultraviolet radiation. The ultraviolet output of the new lamp is approximately one-half of that of the older one. The transformer to be used with the new lamp weighs about 7½ pounds and is small enough so that it can easily be embodied in the design of fixtures, to permit a wider use of this type of lamp, especially a source for dual lighting service.

Still another type of lamp employing a tungsten filament, operated at a high temperature has been found to produce ultraviolet radiation in the biologically active range in sufficient quantity to be of value at least to poultry and animals where exposure times are not too short. Lamps for such service must, of course, be made with special bulbs which will transmit this radiation, and two sizes, 60 and 500 watts for operation on standard lighting circuits have been made available.

A powerful, long-burning type of carbon arc has been developed for the production of ultraviolet radiation which was described in an illumination item in the December issue of the A. I. E. E. Journal, page 1031.

Gaseous Conductor Sources of Light

An arc, in an atmosphere of krypton and sodium, has been described by Dr. M. Pirani.* This operates in a

---

*COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT:
G. S. Merrill, Chairman
J. W. Barker,
A. E. Bettis,
W. T. Blackwell,
H. S. Broadbent,
J. M. Bryant,
W. T. Dempsey,
E. E. Dorting,
L. A. Hawkins,
H. H. Higbie,
W. C. Kalb,
C. L. Kinsloe,
R. D. Mailey,
P. S. Millar,
C. J. Stahl,
G. H. Stickney.

tube about one inch in diameter and 35 inches long which has to be maintained at a temperature of 350 deg. cent. (somewhat above the melting point of lead). A very high efficiency, about 70 per cent of the theoretical maximum, is obtained based on the input to the arc alone. With the supplementary heating required, the over-all efficiency would, of course, be reduced. Previous to this time sodium arcs with efficiencies of from 50 to 70 lumens per watt have been described. The light from such lamps, however, is nearly monochromatic and would, alone, be of limited utility for ordinary lighting service.

Dr. Pirani has also obtained great increases in brilliancy in mercury and in neon discharge tubes.†

The combination of hot cathode neon and mercury vapor lamps to produce light apparently white in color, at a high efficiency, (mentioned in our report for 1928) is again attracting interest, as is also the combination of the mercury arc with incandescent lamps.

Small Gaseous Conductor Lamps

These small negative glow lamps used for night lamps, indicative and current detectors, are now designed to operate on line voltages from 90 to 130, and to consume from 0.01 to 2 watts,. The former is merely an indicator, the latter gives a maximum normal candlepower of 0.2.

Photoflash Lamp

A lamp has been designed to produce a high intensity flash for use in photographic work, consisting essentially of crumpled aluminum foil in an atmosphere of oxygen, which is ignited by a small filament that can be operated on any voltage from 2 to 130. It is made in a bulb of the size and shape of the 100 watt lamp used for general lighting service.

The flash lasts approximately 0.02 second, the radiation is about such as would be obtained from a black body at a temperature of 4,000 deg. K. The flash is equivalent in candlepower to about 250 ordinary 500-watt lamps. It is noiseless and fumeless, the products of combustion being retained within the bulb. The lamp is finding wide use in the photographic field.

40-Watt, Gas-filled Lamp

The 40-watt lamp for ordinary lighting service is being changed from a vacuum to a gas-filled type, and, at the same time put in a slightly smaller bulb. The initial efficiency of the new lamp is slightly higher, and the light output is maintained better throughout life.

50-Watt Lamp

The 50-watt incandescent lamp, for general lighting service, has been removed from the regular schedules of the manufacturers of Mazda lamps. Its demand can apparently be shifted largely to the 60-watt size which is gaining steadily in popularity. The three sizes, 40, 50, and 60 represented unnecessarily close steps.

New Incandescent Lamps

Three new lamps for 110-, 115-, and 120-volt lighting service have recently appeared on the market. These are, a 5-watt lamp in a bulb ¾ inch in diameter, a 100-watt in a tubular bulb 34 inches long, and a 150-watt in a tubular bulb about 12 inches long.

APPLICATION OF LIGHT

Ultraviolet

The utility of ultraviolet radiation for purposes, other than merely the prevention of rickets, has been attracting wide attention and has been the subject of much experimental work. Its most promising physiological benefits seem to lie in the direction of prevention of colds and relief of anaemia. In the industrial field powerful carbon arcs are used for making accelerated tests (which must however be carefully evaluated) and for the treatment of food, tobacco, and other products. Small incandescent sources can be used in poultry houses with good effect.

The use of screens with arc sources to absorb the ultraviolet radiation shorter than that which it is desired to use, has grown during the past year, particularly in outfits intended for use in the home. A time limit switch is also incorporated with some outfits to reduce the probability of over-exposure. The development of very powerful arc sources with long-burning carbons, has extended the possible use of ultraviolet radiation in both industrial service, and in treating large groups in hospitals and sanatoriums.

Trends in Lighting Practise—1930

The interest of architects and decorators in the use of artificial light as a component part of their decorative scheme, is becoming more and more widespread. At first the new ideas were accepted in only the larger cities, now in most of the smaller cities and larger towns excellent examples of the new practise can be found.

Instead of trying to imitate flame sources, candles and oil lamps in fixtures intended for rooms of classical treatment, the skillful designer produces a luminaire which serves the modern light sources in an effective manner and then incorporates in the detail of decoration elements which are inherent to the decorative period under consideration.

The more commercial or stock fixtures which have appeared on the market during the last few months exhibit a tendency to new forms, characterized in general by simplicity of line and pleasing proportions.

If satisfactory illumination is to be obtained from side wall outlets, these must be fitted with some sort of device quite different from the ordinary candlestick bracket. Manufacturers are beginning to realize the possibility of so-called semi-indirect, side wall pockets or urns and a number of interesting varieties have been placed on the market during the period under consideration.

Only a few years ago it was the practise to finish the building and then choose the lighting fixtures. As a result they often tended to appear as an incongruous after-thought, and not a component part of the structure. We are now seeing many instances of what has been termed "built-in" lighting, but these arrangements cannot be carried out unless suitable provision is made in the initial plans for the placement of lighting equipment.

---

*Zeitschrift fur Technesche Physik—Nov. 1930.

†*E. T. Z.*,—June, 1930.

There is a growing appreciation of the value of light to look at (as well as to see by) and in the more modern buildings we see interesting installations of luminous panels, niches, and touches of color which give no useful illumination but are pleasing to the eye.

Naval architects and ship owners realize that their vessels must be made more interesting from a decorative standpoint if they are to attract patronage under conditions of severe competition, and decorative lighting is receiving more attention than ever before in marine service.

There seems to be a trend in commercial lighting practise toward the greater use of indirect lighting equipment, both semi-indirect and totally indirect. Such forms of lighting which are desirable for general use in commercial interiors have been rather slow in being adopted probably because they require better maintenance than the enclosing globes.

Technical progress has been made in practically every field of lighting. In some of the newer ones, such as lighting for outdoor sports and for aviation, there has, in addition, been a very rapid growth. There have been no revolutionary changes, however, in equipment and methods generally employed.

Windowless Buildings

Perhaps the most outstanding development in connection with the use of daylight or artificial light for buildings that has taken place to date was started during the past year. The new factory of the Simonds Saw & Steel Company, Fitchburg, Mass., which is now nearing completion is built entirely without window openings. This pioneering project is receiving much publicity and the results will unquestionably be watched with interest and have a distinct bearing on the future building construction. In this building lighting units consisting of a combination of mercury vapor tubes and tungsten filament lamps will be used to secure a subjectively white color of light. Some of the tubes will be of ultraviolet transmitting glass to provide the desired amount of such radiation. Another notable example of this nature is the Parker Bridget Department Store in Washington, D. C. This store depends entirely on artificial illumination for its operation. It is felt that by eliminating windows lighting conditions are constant at all times. It is much easier to accurately control temperature and ventilation. Then, too, from a merchandising standpoint the larger percentage of wall area is available for display space.

With the record for continuity of service which has been attained by the central stations. and the development of effective means of lighting, ventilation and air conditioning, windows are no longer essential. There are so many advantages to be gained by their elimination in certain classes of use, that it appears as though this subject will receive increasing attention in the future.

Proper Operating Voltage

The N. E. L. A. Lamp Committee gives in its report this year, the results of further surveys of socket voltages, which show some improvement in the average value as compared with the sample cities studied the year before. The spread in voltage, however, shows no improvement. The results given in these surveys apply particularly to residential service. In large office buildings and industrial plants the average socket voltage is probably relatively lower than in residential service because of the greater voltage drop in interior wiring.

The N. E. L. A. Lamp Committee Report for 1928 contained a summary of data on operating voltages as reported in use for some 18,000 communities. This summary showed that 5.4 per cent of the population considered was in communities served at more than one standard voltage. Five years earlier the percentage had been 13.2. This trend toward the use of one standard operating voltage in each community aided in putting lamps of correct voltage in service, because, it is obviously difficult, if not impossible, to avoid mixing voltages in service where two or more standards are in use. The maintenance of but one standard service voltage throughout a community makes it much easier to be sure that lamps of only the correct voltage are used, and this is important from the standpoint of lighting service in general.

Minimum Wiring Specifications

In addition to the minimum specifications for the adequate wiring of lighting circuits in commercial and public structures, mentioned in last years report, specifications covering industrial and residential service will soon be made available as a result of further work by N. E. L. A. Committees. All of these specifications are in such simple form that they can be used with the greatest ease. They provide minimum standards to which all new buildings should conform in the interests of good lighting service. We again recommend that every electrical engineer who is brought into contact with the design or operation of lighting installations should be familiar with these specifications.

Stroboscopic Developments

A new type of stroboscope has been developed in which the discharge characteristics of a three-element grid glow tube are utilized in conjunction with a condenser to produce the brilliant flashes of light of exceedingly short duration and high frequency needed in such work. Another method, described in German technical literature produces flashes of the desired character by the combination of motion of three disks carrying different numbers of radial slits. A more complete description of these devices has been submitted for publication as an Illumination Item.

Group Replacements

The replacement of incandescent lamps in street lighting service in complete groups rather than individually as failures occur, offers a possible means of securing a higher general level of illumination and reducing the number of outages at no increase in operating cost. It is being used, or tried out, in a number of localities. If the burning hours of all the lamps in a large group are identical, and if the cost of replacing lamps individually as they burn out is relatively high, it may be advantageous to replace the entire lot as soon as the burnouts begin to occur with some frequency, which will ordinarily be at the time the lamps have attained about 70 per cent of their average life. If this general replacement is made to coincide with one of the periodic cleanings of the lighting equipment the replacement cost per lamp is relatively small. This same practise might well be applied in other classes of service, where the cost of making individual replacements is relatively high, and where all the lamps in a large group burn the same length of time.

Fixed Focus Automobile Headlights

It has long been recognized that one of the greatest factors contributing toward glare from automobile headlights has been the fact that the lamp filaments were not properly focused in the reflectors. Although the system of approval of headlight equipment by the motor vehicle authorities of the various states after laboratory test has become quite general and all cars are equipped with head lamps capable of producing adequate road light with minimum glare, it has been impossible to keep these equipments in proper adjustment in the hands of the public. The motorists may learn to aim the headlight beams properly, but the more intricate operation of focusing the filament in the reflector has proved a stumbling block.

Because improvements in lamp manufacture now permit more accurate location of the filaments with respect to the lamp base, and because headlight reflector and lens combinations have been designed that are less sensitive to focal adjustment, it has become possible for the motor vehicle authorities to approve the use of so-called "fixed focus" headlamps from which the focusing mechanisms are entirely eliminated. The sockets in these headlamps are rigidly fastened in the reflectors and the filaments in the lamps of any reputable manufacturer in this country are accurately designed to fit them so that an acceptable beam can be secured by simply inserting the lamp in the socket.

Headlamps of this type are already being used by several of the motor car manufacturers and improvements in the general headlight situation are to be expected as their use becomes more widespread and cars with the old types of equipment are gradually replaced on the highways.

GENERAL

Present Status of Candlepower Standards

While the needs of practical photometry have been met reasonably well for many years by the expedient of establishing units of candlepower maintained by means of electric incandescent lamps, this procedure does not give a permanent solution for the problem of photometric standards. There remain unsettled three major difficulties: 1. Several countries, particularly Germany and Austria, still use the Hefner unit, which is 0.9 of the unit recognized by the International Commission on Illumination; 2. no reproducible primary standard has been accepted as representing the international unit which was established for carbon-filament lamps; 3. no specific method has been agreed upon for passing from the carbon-filament lamps to those giving light of other colors.

These difficulties have resulted in discrepancies between measurements made in different countries. The differences are large enough to be very serious in such precise measurements as are made in rating and testing incandescent lamps. Consequently efforts have been made for several years to find a basis for a comprehensive international agreement on this subject. These efforts have been furthered by discussion at several sessions of the International Commission on Illumination. In order to give a more definite legal status to the negotiations the International Committee on Weights and Measures decided in 1929 to take up the problem of photometric units and standards, collaborating with the Commission on Illumination. Both of these organizations meet in 1931, and it is hoped that some definite progress can be made toward the solution of the problem.

As a basis for action, an international Advisory Committee on Electricity, meeting in June, 1930, has prepared recommendations which may be summarized briefly as follows:

1. As a *primary standard of light* a black-body radiator is definitely recommended; other laboratories are asked to consider the specific form of standard which has been developed by the Bureau of Standards, and to make determinations on that form or on others which will be comparable with it.
2. As a *unit* for general use the present international candle is to be retained.
3. Present discrepancies between basic units at carbon-filament color as maintained in the different national laboratories are to be reconciled by comparisons now in progress, and thereafter periodic comparisons and necessary adjustments are to be made under the auspices of the International Committee on Weights and Measures.
4. Through comparisons of colored filters now under way between the national laboratories it is hoped that agreement can be reached on a standard method for measuring lights of various colors. This method can then be used in setting up practical standards for lamps of various types, all based upon the primary standard and all consistent with each other.

Architects and Lighting

During the past year the Illuminating Engineering Society has given great attention to securing better cooperation between the architects and illuminating engineers. As one approach to this problem, three very well attended schools on architectural problems have been held, one at Columbia University, one at Chicago, and one at the Massachusetts Institute of Technology. Such schools for illuminating engineers serve to acquaint them with architects' viewpoints and nomenclature, thus helping to bridge the gap between the two professions. On the part of practising architects greater attention than ever before has been given to coordinating lighting with building design.

Important steps have been taken in fostering better lighting in the homes and schools of the United States. In this manner the best principles of lighting have been made available to school boards and home owners. This work is spreading rapidly.

A code of principles of Street Lighting has been prepared by the Street Lighting Committee of the Illuminating Engineering Society, which is likely to take a very important part in guiding the practise in this field. For the first time experts and engineers representing diverse interests and viewpoints have been able to agree upon a statement of some of the fundamental factors involved.

The Lamp Committee of the National Electric Light Association presents each year to that association a report in which the statistics relating to incandescent lamp production are analyzed in detail, and in which important developments in the production and application of light are reviewed. Those who wish more detailed statistics, as well as those who are concerned with the commercial and engineering problems of lighting, will find valuable the reports of various committees of the National Electric Light Association and the Illuminating Engineering Society.

The Committee wishes to record its appreciation for the assistance rendered in the preparation of this report by Dr. E. C. Crittenden (who contributed the section on the Present Status of Candlepower Standards), Mr. A. L. Powell, and Mr. A. B. Oday.

Applications to Mining Work

ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO MINING WORK*

THERE has been a minimum of new installations made this year owing to the general depression.

Hoists. Probably fewer hoists have been installed than in many past years. It is interesting to note that two manufacturing companies alone report that combined they have sold to date nearly 800 induction motor hoists from 200 to 1,800 hp. in size, and over 100 variable control d-c. hoists from 200 to 5,000 hp., the latter two motors in series.

Cleaning Plants. There is a continued trend toward larger and more complete preparation plants especially at mines using mechanical loading instead of hand loading. One plant, Hazle Brook Coal Co., has installed two 200-hp. Westinghouse synchronous motor drives.

Shovels. Electrification of 4- to 10-yard shovels has continued in the metal mines.

Mining Machines. The manufacturers of this specialized electrically driven equipment have been very active in producing new types of mobile high-powered machines. These machines now undercut from 600 to 1,200 tons per day in contrast with older types which did well to undercut 200 tons per day. See Fig. 1.

Loading Machines. Rapid increase of the amount of coal mechanically loaded indicates that these labor saving devices are permanently established in the industry. Various makes have sustained records of 350 to 500 tons loaded per 8 hours. Probably there are 500 such machines now in operation.

Welding. In addition to miscellaneous repair work by electric arc welding several companies have installed full automatic welding heads to be used for filling up the worn tread of locomotive tires and wheels. This has been quite successful and undoubtedly will be very generally used.

FIG. 1—JEFFREY 29L TRACK-MOUNTED CUTTER

Safety Work. The Bureau of Mines has continued to test and approve many new devices for mining work.

NOTE: Many references to miscellaneous improvements and applications are given in the *Coal Age*, Vol. 36, No. 2, Feb. 1931, p. 76.

---

*COMMITTEE ON APPLICATIONS TO MINING WORK:

C. Lee, Chairman,
A. R. Anderson,
G. Bright,
J. H. Edwards,
F. E. Fisher,
E. J. Gealy,
L. O. Ilsley,
J. E. Kearns,
W. H. Lesser,
D. E. Renshaw,
F. L. Stone,
W. F. Schwedes,
B. F. Tillson,
J. F. Wiggert.

Applications to Marine Work

ANNUAL REPORT OF COMMITTEE ON MARINE WORK*

THE major items of activity of the committee for the current term have been:

a. Reprinting Standards No. 45—Recommended Practise for Electrical Installations on Shipboard.

b. Promoting licensing of the electrical operating personnel on shipboard.

c. Keeping in touch with electric propulsion of ships and the electrification of auxiliaries on shipboard.

STANDARDS NO. 45

During the last term of this committee these standards were completely revised to incorporate developments and expansion in the marine practise since the previous issue of June 1927. They were carefully edited and reprinted in October 1930 and are being rapidly sold to all departments of the marine industry interested in electrical work. These standards are recognized and accepted by the various marine classification and insurance societies, naval architects, marine engineers, shipbuilders, and ship owners and are being incorporated in many of the specifications regulating the construction and repair of ships. The increasing use of them testifies to the need of such rules in order to standardize the electrical installations on shipboard and to stimulate the use and proper care of electrical machinery in the marine field.

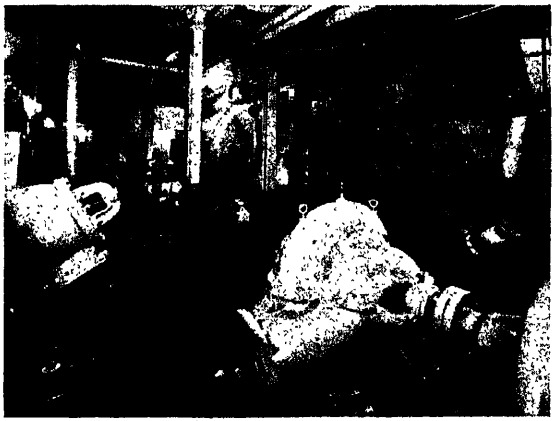


FIG. 1—VIEW IN LOWER ENGINE ROOM, *S. S. Morro Castle*

Propulsion motor in background

They are referred to in the various rules of classification societies not as a requirement but as representing good practise. This regard for these rules is justly merited due to the many years of hard work by experienced representatives of the diversified interests composing the marine field.

The fire alarm rules in the present Steamboat Inspection Service are consistent with the Standards No. 45 and were referred to this committee during their preparation.

OPERATING PERSONNEL

Our efforts were continued with the Steamboat Inspection Service to obtain classification and rating for electrical operating engineers on shipboard.

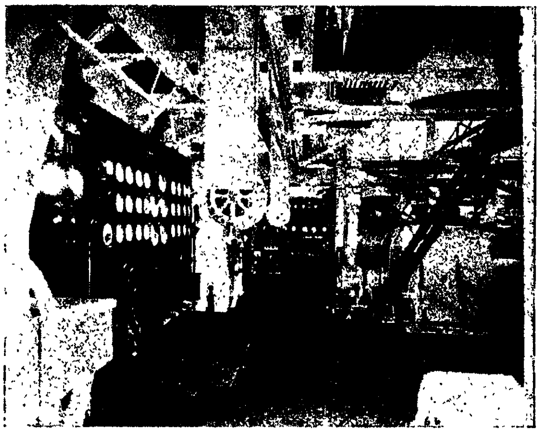


FIG. 2—VIEW IN UPPER ENGINE ROOM, *S. S. Morro Castle*

Propulsion control at left and generators at right

A review of the work of the subcommittee in charge of this item carries one back to the year 1922 when overtures were made to the Steamboat Inspection Service to require the operating personnel on vessels with electric plants to qualify and obtain electrical licenses.

The committee's efforts to date have been rewarded by a slight raising in the standard of the electrical questions in the examination for license for steam and combustion engineers.

---

*COMMITTEE ON MARINE WORK:

R. A. Beekman, Chairman,
E. C. Alger,
H. C. Coleman,
E. M. Glasgow,
H. F. Harvey,
C. J. Henschel,
Wm. Hetherington, Jr.,
H. L. Hibbard,
J. E. Kearns,
A. Kennedy, Jr.,
J. B. Lunsford,
I. H. Osborne,
G. A. Pierce,
W. H. Reed,
E. P. Slack,
H. M. Southgate,
W. E. Thau,
J. Van der Dussen,
A. E. Waller,
O. A. Wilde,
J. L. Wilson,
R. L. Witham,
W. N. Zippler.

The Board of Supervising Inspectors has been very courteous and granted a number of hearings. The necessity for the requested action, is recognized by a few of the supervising inspectors and it is hoped that there will soon be a sufficient number to put the movement into effect.

The cause for this movement was the improper maintenance of electrical equipment on shipboard and is today perhaps more prominent than when the movement was started owing to the increase in the use of electrical apparatus and auxiliaries, with the exception of vessels equipped with electric propulsion and all of these are not immune.

On electrically propelled vessels the standard of the electrical force is somewhat higher than on other vessels. Consequently, the electrical apparatus and auxiliaries receive the benefit of more expert attention.

The committee has been in touch with the President of the American Steamship Owners Association soliciting its good offices. Our committee was cordially received and has been requested to submit its proposal relative to the absence of knowledge and training on the part of the operating personnel. This proposal is almost complete and it is hoped it will be submitted at an early date.

The subcommittee is keeping in close touch with this situation and is optimistic in feeling that favorable action will be taken by the Steamboat Inspection Service before long and their regulations modified accordingly.

ELECTRIC PROPULSION AND ELECTRIC AUXILIARIES

The year 1930 takes its place in marine history of the United States with a record of activity, progress, and accomplishment in shipbuilding and marine engineering, which has not been approached since the busy days of the World War. This is, of course, due largely to the stimulation resulting from the Jones-White Merchant Marine act of 1928, which has made available to American ship operators, large mail contracts and loans at low interest rates for construction of new vessels. Thus, our merchant marine is to receive a much needed strengthening by the addition of a fleet of fine ships now under construction or in process of design.

In the design of these last words in naval architecture, electricity has taken an outstanding place. Some will be propelled by means of electricity. All will have electrically driven auxiliaries which are so necessary to the operation of the ship. Electrical appliances will add to the comfort and convenience of the passengers.

In order to illustrate the progress of electric propulsion especially during the past year the following data covering vessels completed or contracted for to January 1, 1931, are listed below.

	Hp.	No. vessels
Total turbine electric in U. S. A.	867,600	62
Total turbine electric outside U. S. A.	127,900	9
Total	995,500	71
Commissioned or under construction during 1930 in U. S. A.	196,900	20
Total diesel electric in U. S. A.	88,280	121
Total diesel electric outside U. S. A.	16,700	8
Total	104,980	129
Commissioned or under construction during 1930 in U. S. A.	15,195	25

It may be interesting to know the individual vessels and their horsepowers involved in the above figures.

Name		Horsepower
Turbine Electric Drive—Ships Commissioned During 1930 in U. S. A.		
Santa Clara		12,600
Morro Castle		16,000
Oriente		16,000
City of Flint (Great Lakes Car Ferry)		7,200
Corsair		6,000
4—Coast Guard Cutters		12,880
2—River towboats		4,000
Total		74,680
Turbine Electric Drive Equipments—Under Construction During 1930		
President Hoover		26,500
President Coolidge		26,500
United Fruit Co.—6 ships 11,000 hp. each		66,000
One Coast Guard Cutter		3,220
Total		122,220
Diesel Electric Drive—Installed During 1930		
Frying Pan	Lightship	350
Fenwick Island	Lightship	350
Nantucket	Lightship	350
Tidewater	Tanker	1,000
Ward Island	Ferry	400
Tenkenas	Ferry	400
Veedol No. 2	Tanker	1,000
L. T. C. No. 1	Tanker	500
L. T. C. No. 2	Tanker	500
L. T. C. No. 3	Tanker	500
Liston	Survey Boat	350
Scott	Towboat	150
Ft. Armstrong	Towboat	150
Cleveland	Tug	800
Rochester	Tug	800
Scranton	Tug	800
Oleon	Tug	800
Venus	Tug	515
Luna	Tug	515
Prescottont	Tug	800
One tug *Vandyke No. 4.*		425
Total		11,455
Diesel Electric Drive—Under Construction		
One yacht		660
One tanker		200
One fireboat		2,130
One ferryboat		750
Total		3,740

Prior to the commissioning of the *S. S. California* in 1928 the total turbine-electric horsepower installed on merchant ships was but 38,800. Out of a total of 356,200 horsepower completed and in course of construction as of the end of 1930, 317,400 horsepower, or

89 per cent, was undertaken during the past three years.

Slightly apart from the marine field, but with equal interest to it, was the installation of a central station in the *Jacona,* which is to be used as a mobile and subsidiary power plant along the shores of the New England Coast. Two turbine generators were installed, each rated 10,000 kilowatts for delivering power ashore at 6,600 volts or 11,400 volts three-phase 60 cycles.

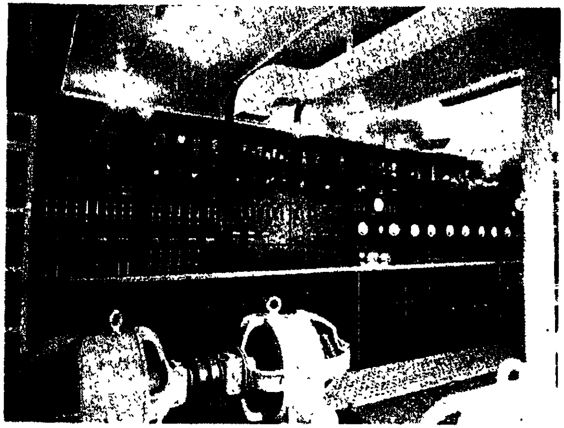


Fig. 3—Auxiliary D-C. Switchboard, *S. S. Morro Castle*

During 1930, a 96-in. (wheel diameter) gyroscopic stabilizer complete with electrical equipment, was constructed. This unit will be installed in a large yacht. A second unit with 11-ft. diameter wheel, complete with electrical driving motors, control and turbine generator set for power supply, is nearing completion for installation on one of the largest yachts ever built. The casing of this stabilizer will be of welded construction.

During the year 1930 great strides were made in shipboard installations of modern watertight door control systems. This system provides that in the event of collision electric operation of the watertight bulkhead doors is instantly available. The system provides remote control of the watertight doors from the wheel house as well as at the door itself.

It is the intention of this committee to keep Standards No. 45 up to date and assist in any practicable way the various classification societies and other bodies or interests in the marine field in the application of electricity to marine use.

We further are ready to cooperate with the American Marine Standards Committee in establishing electrical marine standards such as watertight receptacles, etc.

Power Generation

ANNUAL REPORT OF COMMITTEE ON POWER GENERATION*

TWO meetings of the entire committee were held during the year, one at the Philadelphia District Meeting on October 14, 1930, and the second at the Winter Convention in New York on January 28, 1931. In addition to the regular survey of immediate developments and problems in the scope of the committee, a continuing organization or method was adopted through which news items on the subject of power generation will be reported for publication in ELECTRICAL ENGINEERING. Each member of the committee was asked to appoint some one of his business associates as a permanent news correspondent to represent his particular affiliation irrespective of membership in the future on the Power Generation Committee.

The subject of interconnection continued to occupy the major attention of the committee, and especially of the Joint Interconnection Subcommittee on which Messrs. F. C. Hanker, F. H. Hollister, and A. E. Silver represented the Power Generation Committee. The formation of this subcommittee composed of members from the Power Generation, Power Transmission and Distribution and Protective Devices Committees, was predicted in last year's report, and the subcommittee has functioned throughout the year under Mr. Hanker's chairmanship not only to the fullest extent, but has also promoted a close working arrangement among the three main committees in dealing with a subject that has many common elements.

The Joint Interconnection Subcommittee has directed the preparation of a second report on "Grounding," which was presented at the Pittsburgh meeting in March 1931 under the title *Present Day Practise in Grounding of Transmission Systems*, and while of technical import to this committee, is also of interest because the original report on *Grounding* was prepared in 1923 by Mr. E. C. Stone now of the Power Generation Committee.

The Interconnection subcommittee has also sponsored a session in this summer's convention, consisting of four papers that treat the subject of interconnection primarily from the viewpoint of geographical, as contrasted to urban territory, interconnection. The introductory paper, prepared by Mr. Alex. E. Bauhan, is a comprehensive summary of the various services rendered by interconnection, and an exposition of the methods of evaluating the economies to be secured. Two papers that illustrate the plans and operating procedures adopted in different regions, are as follows:

Interconnection in New England, by E. W. Dillard and W. R. Bell; *The Pennsylvania-Ohio-West Virginia Interconnection*, by Howard S. Fitch.

The fourth paper, by G. M. Keenan, is on *Load and Frequency Control on Interconnected Systems* and summarizes the methods in use and the experience on the subject that has accumulated in the past two to three years on practically all the major system interconnections in this country.

The committee reviewed during the year and recommended as of great interest on the subject of interconnection other papers as follows:

Governor Performance During System Disturbances, by R. C. Buell, R. J. Caughey, E. M. Hunter, and V. M. Marquis.

Reestablishing Excitation of a Loaded Alternator in Parallel with Others, by D. D. Higgins and E. Wild.

Other papers describing the design of modern power plants that have been reviewed by the committee include the following:

The Ohio Falls Hydroelectric Station at Louisville, Kentucky, by R. M. Stanley and E. D. Wood.

Modern Steam Stations of Duke Power Company, by Marshall E. Lake.

Steam Power Development of the Pacific Gas and Electric Company, by Richard C. Powell.

Two papers with an introductory summary have been initiated and are now in preparation on the subject of steam and electric drives. These papers are being written in collaboration for the purpose of uniform presentation, and are scheduled for one of the fall meetings this year.

Another activity initiated that will result in a symposium during the 1932 Winter Convention, is suggested by the lack of information reported to the committee on the subject of system operation from the viewpoint of economy and reliability in carrying load schedules. There is considerable literature relating to load division among boilers and generating units in single stations, but new problems in load allocation have resulted from the extensive interconnection of systems previously operating as separate units. It is planned to secure a series of papers describing the practise of at least three of the larger operating systems on which steam generation is exclusively employed, and to reserve the subject of combined steam and hydroelectric sources for later discussion.

---

*COMMITTEE ON POWER GENERATION:

F. A. Allner, Chairman,
F. A. Annett,
J. R. Baker,
T. J. Bostwick,
J. B. Crane,
H. W. Eales,
N. E. Funk,
D. L. Galusha,
R. B. Gerhardt,
W. S. Gorsuch,
F. C. Hanker,
C. F. Hirshfeld,
F. H. Hollister,
A. H. Hull,
G. A. Jessop,
H. W. Leitch,
E. B. Meyer,
E. L. Moreland,
I. E. Moultrop,
G. E. Quinan,
F. A. Scheffler,
A. E. Silver,
W. F. Sims,
A. R. Smith,
E. C. Stone,
R. W. Stovel.

The Progress Report which follows, covers the developments of the past two years. Together with a bibliography of the more salient literature on power generation.

RECENT DEVELOPMENTS AND PRESENT STATUS OF POWER GENERATION

Volume and Distribution of Generation

The combination of a two-year drought and the business depression had a marked effect upon the distribution of the total electric generation in the United States between fuel burning and hydroelectric plants. From 1921 and 1928 the average yearly increase in total generation was quite uniform at 11.5 per cent, in fuel generation at 10.9 per cent, and in hydroelectric generation at 12.7 per cent. Applying these average rates to the figures for 1928 there is a calculated deficit at the end of 1930 of 12.1 per cent in total generation, 4.0 per cent in fuel generation, and 32.5 per cent in hydroelectric generation. These figures show that the loss in hydroelectric generation caused by the drought allowed fuel generation almost to hold its normal increase notwithstanding a decrease of 1.5 per cent in total generation in 1930. The total generation in 1930 was 96 billions, of which 34.6 per cent was generated in hydroelectric plants in contrast to 40.4 per cent in 1928.

Generating Plant Building Programs

The added steam generating capacity in the United States in 1929 was secured by about 57 per cent in new plant construction and 43 per cent in additions to existing plants. The total added capacity was nearly 2,250,000 kw. It is interesting to note that in 1930, in spite of the fact that the total electric production for the year was about 1.5 per cent below that of 1929, there was nearly as much steam generating plant capacity added as in 1929, a total of slightly over 2,000,000 kw. This was divided 47 per cent in new plants and 53 per cent in additions to existing plants. Apparently the depression of the past year is to be reflected in the amount of capacity contemplated for 1931 additions, which is about 1,250,000 kw. These additions are mostly in existing plants where the added capacity is 75 per cent of the total, a condition approaching that of 1928, when practically all of the new steam capacity was in additions to existing plants.

Compared to 1928, the number of new hydroelectric plants and the capacity installed in 1929, was strikingly small; the new installations in 1930 were over three times greater than in 1929, but they still were appreciably less than in 1928. The plants now under construction that will be completed in 1931 will total about 50 per cent of the additions to capacity in 1928, while present indications are that the new capacity developed in 1932 will be only a fraction of the 1931 installations. Contrasted to the schedule of immediate construction are the probabilities within the next few years of the super-capacity plants that are being considered on the Columbia, Colorado, and St. Lawrence rivers.

Major Influences in Current Design of Steam-Electric Plants

The fundamental factors influencing the design of modern steam-electric generating plants are about the same as those which dictated design in the past. They are only modified by new and better apparatus now available, such as improved and alloy steels which make possible the use of higher pressures and temperatures, improved fuel burning equipment and furnaces which permit of much higher boiler ratings and greater efficiences, together with numerous other improvements in auxiliary apparatus.

For a number of years the tendency of steam plant investment costs was upward and these increased costs were justified by the considerable improvement in economy. The point has now been reached where improved efficiencies are becoming increasingly difficult to secure, and any increase in capital cost is difficult to justify. It would seem, therefore, that the effort to lower production costs must lie in reductions in capital investment through simplified design, raising the output of the equipment, and increasing the capacity for a given unit of space.

Probably the most attractive feature in a program of simplification is the possibility of reducing the number of boiler units for a given turbo generator output. Reports published within the last year indicate that the modern boiler has a reliability factor practically equal to that of the turbo generator. It would, therefore, seem that spare boiler capacity should be considerably reduced over past practise up to the point where boiler and turbine capacity would be equal. In other words, the boiler and turbine might be considered as one complete unit. This would be particularly practical where there are several units in the same station, in which case a certain degree of flexibility could be secured where a boiler and turbine forming separate units might be out of service, in the one case for boiler inspection or repairs and in the other case for turbine inspection or repairs.

The greater cleanliness in the operation of fuel preparation and feeding apparatus will now permit the installation of turbines, boilers, and fuel equipment in single buildings without the use of the dividing walls which have up to this time been considered necessary. There has been a number of instances where plants have been constructed without these walls and are giving very satisfactory operating results. The omission of dividing walls not only saves the cost of the wall but reduces the amount of building steel and permits of a more compact arrangement of apparatus, thus bringing about a natural reduction in the cubic contents of the building. In certain cases a reduction in operating labor has also been secured.

Outdoor installations of boilers, turbines, and electrical equipment are advocated by some engineers and many attractive studies have been brought forth. To date, however, no large outdoor installations have been projected. While such installations are not in entire favor with operating engineers the reduced investment has made the designs of interest.

In practically all of the older designs there was a great deal of duplication in the piping layouts. Numerous cross connections, loops and sectionalizing valves were used, partly with the idea of protecting against failure of any part of the piping system and partly due to the desire to protect against failure of apparatus used in the feed-water heating cycle. Experience with operation of piping, valves, and equipment has shown that their factor of reliability is, in general, as great as that of the turbines and boilers. The opinion has frequently been expressed that provisions made for cross-connecting and sectionalizing have never been used even though they have been in the plant for a considerable number of years. Simplification of piping design and reduction in number of valves, joints, etc., would reduce both the capital expenditure and the operating cost.

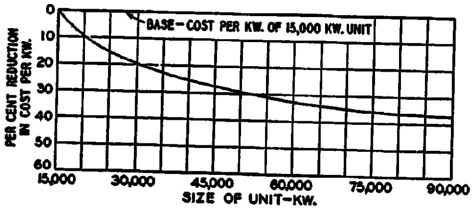


FIG. 1—PER CENT REDUCTION IN UNIT COST OF SINGLE SHAFT TURBO-GENERATOR UNITS DESIGNED FOR 450 LB. 775 DEG. FAHR. STEAM

Considerable thought has been given to reducing the number of duplications of auxiliary equipment, such as condensate, air and circulating pumps for turbo generator units. In designs where several spare boilers were provided it was the practise to install single auxiliaries such as stoker drives, forced and induced draft fans, whereas on the turbo generator units it was customary to duplicate the auxiliary equipment. With the present consideration being given to reduction and possible elimination of spare boilers, the question of duplication of auxiliaries should be carefully considered. The usual argument that it is good insurance to protect the large unit by the installation of duplicate and comparatively cheap auxiliaries, carries some weight. Against this, however, must be balanced the lower capital and operating costs by minimizing the number of pieces of apparatus and simplifying the piping design.

The use of larger units, both boilers and turbines, has resulted in a lower unit cost of equipment and in a marked reduction in the cost of the building per kilowatt of capacity. There is a number of installations either already made or pending, where the capacity of the new turbo-generator unit is from two to three times that of the unit for which the building was originally planned. It is evident, therefore, that the cost of this portion of the building per kilowatt would be reduced to one-half or one-third of the original cost. A few years ago the cost of buildings per kilowatt of capacity was roughly $30. It is, therefore, evident that the possible savings in building alone due to use of larger equipment results in a material reduction in cost per kilowatt. This would have a particular application where equipment is to be installed in a vacant space in an existing building or where it is desired to increase the capacity by replacing equipment in an old plant which is strategically located in the distribution system.

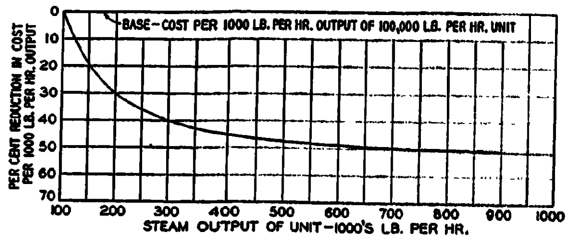


FIG. 2—PER CENT REDUCTION IN COST OF BOILER UNITS DESIGNED FOR 450 LB. 775 DEG. FAHR. STEAM

Prices used in plotting the curve include cost of boiler, superheater, soot blowers, air heater economizer, and pulverized fuel equipment

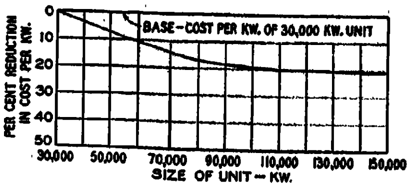


FIG. 3—PER CENT REDUCTION IN COST OF SINGLE SHAFT TURBO-GENERATOR UNITS DESIGNED FOR 1,000 LB. 775 DEG. FAHR. STEAM REHEATED TO 775 DEG. FAHR.

The reduction in floor area has assumed importance not only from the standpoint of building and land value but from the resulting reduction in cost of much of the piping and auxiliary equipment. In order to reduce the floor area some of the modern designs resorted to the vertical compounding of units as typified by the Jersey Central Power and Light Company and the Pacific Gas and Electric Company where a high pressure turbine and generator are mounted on top of a low-pressure generator. By such means and by the increase in the maximum size of turbines from 50,000 kw. in 1920 to 200,000 kw. at present, the floor area has been reduced from an average of 42 sq. ft. per installed kilowatt to less than half that area.

Typical of this trend are the Ford Company in which a 110,000-kw. unit is to be installed where one 12,500-kw. unit is being removed; the Hell Gate Station of The United Electric Light and Power Company where two 160,000-kw. units have been installed in the space designed for two 35,000-kw. units and the Hudson Avenue Station of The Brooklyn Edison Company, Inc., where two 160,000-kw. units have been purchased for the space designed for two 50,000-kw. units.

Along with the increase in size of turbines the weight per kilowatt including the generator has been reduced in the past ten years from about 28 lb. to 15 lb.

The curves in Figs. 1, 2, and 3 will give an indication of the trend toward lower costs with increased size of turbo generators and boilers per unit of capacity. Figs. 1 and 2 represent respectively cost trends for turbo generator and boiler units designed for 450 lb. pressure and 775 deg. fahr. total temperature. Fig. 3 is representative of a compound single-shaft turbo generator where the initial steam condition would be 1,200 kw. and 775 deg. fahr. total temperature, with steam bled at 400 lb. and reheated to the initial temperature.

Along a line totally different from the selection and arrangement of equipment, and also for the purpose of reducing the cost of power generation, has been the cooperative interconnections adopted in the last few years between steam-electric stations and industrial plants. The latter in some cases require large quantities of steam under conditions that may or may not be suitable for the supply of power necessities; in other cases the industrial plants may have the disposal of byproduct fuel either solid or gaseous. It has been found advantageous to both parties in a variety of industries to arrange both electric and steam interconnections whereby power and steam are generated in the most economical fashion, and the fullest benefit derived from diversity in power, steam, and byproduct conditions. In many instances the electric plant supplies both steam and electricity, requiring certain modifications in the standard feed water system. Recent literature has described such arrangements at Deepwater, New Jersey, Rochester, New York, Toledo, Ohio, Baton Rouge, Louisiana, Mobile, Alabama, and Cedar Rapids, Iowa.

Factors at Present Determining Maximum Size of Boilers and Turbines

While large unit size turbo generators reduce the cost per installed kilowatt they sometimes represent a greater capital charge for reserve capacity. A check of available published information regarding peak loads and installed capacity in fourteen large central station systems indicates the following reserve capacity in per cent of the total installed:

Four systems were between 30 and 36 per cent.
Seven systems were between 20 and 30 per cent.
One system was about 17 per cent.
Two were less than 10 per cent.

The same published information indicates that the two systems having the smallest reserve capacity have a substantial percentage of purchased power, so that it is very probable that actual reserve capacity would be materially increased by available spare capacity through interconnection. In one of these systems, where the per cent of reserve capacity is the greatest, it is known that the generator capacity reported on was not all available at the time the tabulation was made, since the boiler capacity in one of the principal plants limited its capacity to a point considerably below the generator name plate ratings. The selection of the very large units in some of the recent developments may have been due to a program of interconnection or expansion which it was estimated would occur within a few years following the installation of the new machine.

Allowance must be made for the loss of the largest unit during operation and also for the possibility of its being out for repairs. If, therefore, units are purchased out of proportion to the size of the system there is likely to result an over-all economic loss. Large units show better performance at comparatively heavy loads. Due to the system reserve requirements it may be necessary to operate at a relatively light load where the economy is poorer. Even the smaller units operating may be affected the same way from the fact of the larger units being on the system. With large units the total amount of auxiliary power requirements for any given system output will also be increased at low system loads. With a large unit carrying heavy load a greater system disturbance would result if the unit should suddenly trip out. Other things being equal the time required for starting a large unit is greater than for one of smaller size.

Transportation difficulties for damaged parts, a longer time necessary for repairs, and larger floor area necessary for dismantling are some of the factors which must be weighed against the lower unit investment and lower labor charges.

Turbine manufacturers have indicated that up to 200,000-kw. capacity in single shaft machines would be feasible. By compounding on multiple shafts the limits, of course, would be considerably higher. One of the limiting features in size would be in connection with the generator and here the use of double windings or raising the voltage will offer a partial solution of the electrical problems.

The limitations to the building of large boilers are more structural than economic. Since at present larger capacity is concentrated in single turbines than in single boilers the problem of boiler reserve is of less importance. Also the experience with pulverized fuel boilers having capacities in the neighborhood of

1,000,000 lb. of steam per hour indicates an availability factor during demand periods approaching 100 per cent.

Large boilers have an exceedingly flat efficiency curve and can be operated at relatively low loads at efficiencies equal to that obtainable from boilers of smaller size. The parts involved in boiler construction are small and do not involve any transportation problems.

Rehabilitation of Existing Steam Plants

Many studies are still being made by steam station designers to increase station capacity by means of improved thermal cycles using higher temperatures and pressures, but not much actual revamping has taken place in the past year or so because of the falling off in power station demand and construction. Then again, while many studies of rehabilitation have been made, all recent improvements in steam station design have been quite broad in their application involving considerable major equipment. Generally speaking, where there has been a demand for increased capacity it has been for such large increments that invariably more consideration is given to the building of new stations with units of large capacity than to some modification of existing generating facilities.

Some steps looking to improved steaming have been taken, such as the installation of water-cooled walls frequently combined with pulverized fuel firing with resultant greater output from the same boiler; also, the installation of air-heaters resulting in a reduction of stack losses. Recent studies made on binary cycles indicate that improvements in efficiency can be made in old plants employing old boilers.

The important recent developments of interest to steam station designers both in the United States and abroad which will, no doubt, in the future have a great influence on rehabilitation, have been:

a. The installation of a 10,000-kw. mercury turbine in the South Meadow Station, Hartford, Connecticut.

b. The installation of high-pressure steam (750 lb.-2,800 lb.) units at Langerbrugge Power Station in Belgium.

c. The construction of new peak load plants in Germany of low pressures.

d. The construction of heat storage plants in Germany.

Rather than follow these lines of securing an increase in capacity and improvements of economy by changes in old stations, the trend in American practise is, with a few exceptions, more along the lines of building new efficient high-pressure steam plants and utilizing interconnections to a greater degree for permitting the operation of the new stations at high capacity factors on base load, and retaining the older less efficient stations for peak loads. With ample interconnections, addition of new capacity at old load centers is not often thought to be as economically advantageous, everything considered, as establishing new generating points where ample land, rail, and water facilities are available.

Reduction in Operating Costs of Steam-Electric Plants

The production of electricity from steam central stations has developed so remarkably in the last decade that it seems fitting in this report to review the progress that has been made during this time.

The average unit production cost has decreased about 50 per cent. The heat consumption per kilowatt hour has been reduced from about 30,000 B. t. u. in 1920 with a best record of 18,000, to an average of 18,500 B. t. u. in 1930 with the best record approximating 12,500 B. t. u. This is for stations using steam only. The mercury steam cycle installation at the South Meadow Station of the Hartford Electric Light and Power Company reports an average heat consumption of around 10,500 B. t. u. per kw-hr.

The progressive increase in the size of turbo generator and boiler units together with the improvements that have resulted in the reduction of supervisory requirements have brought about a constant decrease in labor costs. Great improvement has been made in control equipment with the consequent extension of the scope of supervision of individual operators.

Boiler maintenance costs have been reduced by the use of cooled furnace walls and from the studies by engineers of the effect of operating conditions on maintenance, with a consequent increase in availability of equipment.

Allocation of the load to various stations of a system on a basis which gives a minimum combined cost for each momentary change in load demand and at the same time taking into consideration the effect of loading on the maintenance of equipment, losses incidental to starting and labor costs, has brought about a great reduction in operating costs.

For example, for any particular load demand on the system there is one combination of units and loads at the various stations which will give the lowest combined cost for the system. The determination of this equipment set-up is made by grouping various combinations of units at the different stations through the use of cost input-load output and incremental cost characteristics of the units.

These cost input-load output and incremental cost characteristics are computed from tests on the equipment and it is very important that these tests be obtained with a high degree of accuracy. An operating factor based on a knowledge of the performance of the unit under normal conditions of operation is applied in order to obtain the true normal operating characteristic of the unit. The amount of equipment and location of equipment operating at the various stations must in all cases conform to the standard system operation reliability, which takes into consideration such factors as physical layout, storms, voltage regulation, and protection of the load.

With the determination of the amount of equipment operating at the various stations any change in system demand will be made on the basis of the station incremental cost curves for the equipment operating to a point at which it becomes more economical to operate on another set-up. This method of loading for every momentary change in demand gives a minimum cost for all ranges of load, limits the number of units operating to those required for economy and reliability, and results in a greater utilization of the more efficient units.

In the case of one large power system during the last year the generating capacity of the system was increased about 2 per cent whereas the output delivered by the newer units was raised 13 per cent. As a matter of fact on that system during the year 1930 considerably more kilowatt hours were generated than in 1929 at a total production cost lower than that of 1929.

Table I shows the actual operating results obtained from several different types of stations. The low heat rate obtained by Station A indicates the possibility of a greater adoption of the mercury steam turbine in the near future.

TABLE I—RECENT OPERATING RESULTS

Station	Pressure lb./sq. in.	Temperature deg. fahr.	Cycle	Load factor per cent	Period	Heat rate B. t. u./net kw-hr.
A	70	884	Mercury		Dec.-Feb. 1930	10,180
B	1200	750	Reheat regenerative	72.9	Oct. 1930	13,910
C	350 600	725	Reheat regenerative	65.5	Dec. 1929	12,455
D	1250	750	Reheat regenerative	52.0	Oct. 1930	14,091
E	600	725	Reheat regenerative	71.5	Oct. 1930	14,581
F	600	730	Reheat regenerative	62.7	Feb. 1930	13,368
G	400	725	Regenerative	54.8	Oct. 1930	16,290
H	250 400	700	Regenerative	59.3	Oct. 1930	15,712

Technical Developments in Steam-Electric Plant Design

The seven high-pressure stations described in the last report have been in operation long enough to confirm the results expected from them. Excepting continuing trouble with boiler feed pumps in some of the plants, no unsolved difficulties have been encountered. The more prominent additions to the list of high-pressure plants within the past two years have been the State Line plant near Chicago, the River Rouge plant of the Ford Motor Company in Detroit, and the Port Washington plant of the Milwaukee Railway and Light Company.

State Line plant, described in previous reports, was placed in operation in 1929 with a single three-element turbo-generator unit of 208,000-kw. capacity. The initial steam conditions were 630-lb. pressure and 730 deg. fahr. The extension to the plant now under construction includes two single shaft units of 150,000- and 125,000-kw. capacity respectively. The steam conditions will be 1,200 lb. and 825 deg. fahr., using boilers fired with pulverized coal from unit type mills. An interesting feature in connection with the turbines will be the reheating of steam from the high-pressure cylinder to 825 deg. fahr. at 400 lb. pressure, and its reintroduction into the high-pressure cylinder for expansion to the cross-over pressure of 15 lb. absolute. Reheating will be done in boilers of the reheat type.

River Rouge plant starts operation this year of the very interesting steeple compound 110,000-kw. turbo generator. The initial steam condition is 1,200 lb. at 750 deg. fahr. Live steam reheaters will raise the temperature of exhaust steam from the high-pressure element to 550 deg. fahr. at 80 lb. absolute pressure before it enters the low pressure element. Of particular interest is the fact that this new machine is installed in space originally occupied by two 12,500-kw. turbines and sufficient space will remain for the addition of a second 110,000-kw. unit of the same type at a later date. Two boilers, each having a maximum steam capacity of 700,000 lb. per hour, will serve this turbine.

The Port Washington plant will have one boiler of 690,000 lb. of steam per hr. to operate at 1,300 lb. pressure and initial and reheat steam temperatures of 825 deg. fahr.

In the realm of boilers for pressures above 1,400 lb. there has been no development except in that of size. The Benson and Loeffler boilers are now being built in Europe in capacities above 100,000 lb. of steam per hour; three Loeffler boilers, each with a designed output of 150,000 lb. of steam per hour at 1,850-lb. pressure and 932 deg. fahr. have recently been ordered for a plant in Czechoslovakia. The Benson boiler in use at the Langerbrugge plant in Belgium produces 220,000 lb. of steam per hour at 2,270-lb. pressure. An experimental boiler to operate at 3,200 lb. pressure, being installed at Purdue University, will be the first at that pressure in America. Boilers for 1,800 lb. pressure to supply steam to two 6,400-hp. triple expansion engines are now in course of erection at the Philip Carey plant in Cincinnati. The design of European types of high-pressure boilers was reviewed in the 1929 report.

There is some evidence that the average steam temperature in large power plants in this country has increased slightly during the past two years, and the maximum temperature in use is now considered to be approaching 800 deg. fahr. The Langerbrugge plant in Belgium has operated at a temperature of 850 deg. fahr., for 4½ years and in general there is more of a tendency to use extremely high temperatures in Europe than in this country. In certain respects modern European boiler designs lend themselves to the generation of high temperature steam, and the practise of multi-barrel turbines, common in Europe, is also adaptable to its use. In the United States the Detroit Edison Company has recently put into operation a 10,000-kw. turbo generator at its Delray No. 3 plant, designed to use steam at 1,000 deg. fahr. At the present time the turbine is operating on steam from the station main under 400 lb. pressure and at 750 deg. fahr. For high temperature operation the supply steam will be passed through a separately fired superheater using oil for fuel. The steam main between the superheater and turbine is provided with several types of pipe joints, and other arrangements have been made to note the effect of the high temperature upon the piping, turbine, and superheater, so that the installation constitutes in reality a full scale experimental investigation.

During the past two years the mercury vapor boiler and 10,000-kw. turbine installation of the Hartford Electric Light Company has been perfected to the point where it was available for 82.3 per cent of a period covering 7,520 hours. Excluding causes arising from the use of mercury, the installation would have been available 95.1 per cent of the time. The average thermal rate was 10,310 B. t. u. per net kw-hr. Of the total energy generated, 42.5 per cent was produced by the mercury turbo generator, and the remainder by the steam formed in the mercury condenser.

As a result of the experience at Hartford, mercury vapor units of 20,000-kw. capacity each are being planned for the Kearney plant of the Public Service Corporation of New Jersey and for the power plant of the General Electric Company at Schenectady. The latter installation and an associated steam boiler will be one of the first outdoor steam plants. The mercury vapor pressure will be increased to 125 lb. per sq. in. in these new units, and it is expected that a thermal rate of 8,800 B. t. u. per net kw-hr. will be secured at a load of 20,000 kilowatts on the mercury turbine and with the power developed from the 240,000 lb. of steam per hr. produced at 400 lb. pressure in the mercury condenser.

Higher steam pressures and investigations of troubles resulting from caustic embrittlement have indicated the desirability of boiler drums without seams. Forged drums have been used exclusively for the 1,400-lb. boilers, and lately hammer-welded drums for medium pressure boilers such as the four drum boilers in the James H. Reed Station of the Duquesne Light Company in Pittsburgh, that operate at 400 lb. pressure. The possibilities of fusion welded boiler drums have been studied intensively in the past two years, and "Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers" were published in the March 1931 issue of *Mechanical Engineering.* The Boiler Construction Code does not at present permit fusion welding of parts where the safety of the structure is dependent on the strength of the weld.

While no boiler installations have been made of rger capacity than those in the East River and Hell Gate plants in New York that were described in the last report, operating experience at the East River plant has shown that loads can be carried on the boilers there considerably in excess of the expected capacity. A unit generation of 1,250,000 lb. of steam per hour has been maintained, the actual operating limit being met in the capacity of the steam piping leading from the boiler unit. A boiler of 1,000,000 lb. per hr. capacity was recently installed in the Kips Bay plant of the New York Steam Corporation on a floor area originally allotted in 1926 for a boiler of half the output. These large boilers are in reality twin-set boilers having two independent water circulating systems and steam uptake connections, located over a common furnace. The largest single boiler to date has a capacity of about 600,000 lb. of steam per hour.

The installation of boilers of large capacity has focused the attention of operating and designing engineers upon the problem of boiler availability. Although in most plants the number of boilers still exceeds the number of turbo generators, boiler outage in many cases impairs to some extent a plant's generating capacity. Protection of the furnace walls with water cooling surface, improved reliability of the coal feeding and burning equipment, as well as of the ash handling apparatus, increased attention to the details of the auxiliary apparatus, and correct boiler water conditions, have resulted in numerous instances of boiler availability equal to that of turbo generators. The first statistical study of this subject on a large scale was directed in 1929 and 1930 by Mr. C. F. Hirshfeld of this Committee, and was published in *Transactions,* A. S. M. E., Vol. 52, No. 27, p. 265. The data compiled covered only a year and there were several other reasons why the statistics were necessarily inconclusive, but they seemed to indicate that the details of design and construction and operating skill are more important in obtaining high boiler availability than such matters as rate of output per unit of surface, type of fuel, and method of firing. The average availability factor appeared to be between 84 and 90 per cent.

During the period being reviewed, the point of major technical interest in connection with the pulverized coal method of combustion has been the long-time comparisons in the same plant of the unit and bin systems. No generally accepted opinion regarding their merits has been reached. Both systems were installed in the Deepwater plant, New Jersey, where it has been reported that the unit method of firing gave a higher efficiency but a lower reliability. Other comparative studies have been recently published for central stations in Chicago and St. Louis.

Experimentation has continued with the slag tap type of furnace for pulverized coal firing, and its use has been extended. The major difficulty has been the gradual expansion in a horizontal plane of the furnace floor, with consequent bulging of the furnace walls. This results from penetration of the hearth bed by the molten slag, through cracks formed when the furnace is cooled during boiler shutdowns.

The size and total fuel burning capacity of underfeed stokers continue to increase, and steam outputs per boiler of 500,000 lb. per hr. are now possible with stoker firing. There has been only a foot increase in the maximum width of stokers in the last ten years, but the length has been increased from about 13 ft. to 26 ft. 7 in. The largest underfeed stoker in this country is now being installed in the Hudson Avenue plant of the Brooklyn Edison Company, and will be 26 ft. 7 in. long by 26 ft. wide, with a grate area of 694 sq. ft. Stokers of this size have been made possible by extensive cooling of the furnace walls by water cooled surface, improved coal feeding and distributing mechanism, and better control of the air distribution to the several parts of the grate surface and ash pit. In come cases automatic control of the air distribution has been installed. Rotary ash dischargers are almost standard for the larger size of stokers.

Although the fuel burning capacity of stokers per foot of width has been greatly increased, there has been no increase in the rate of combustion per square foot of total grate surface, which is limited by the possibility of clinkering and the blowing of coal from the firebed. Neither has there been any modification of the fact that the combustion rate depends upon the type or burning characteristics of the coal burned. Maximum rates of 60 to 70 lb. per sq. ft. for 10 hour periods have been maintained with good quality eastern coals; 50 to 60 lb. with coals from the central field. Slack coal reduces the maximum rate to the neighborhood of 40 lb. per sq. ft. With all coals an increase in the combustion rate results in an increased loss from incomplete combustion, cinders, soot, ash pit, radiation and unaccounted for losses, in some reported tests these losses reaching a value of 20 per cent.

The limiting temperature for preheated air with underfeed stokers seems to be in the neighborhood of 350 to 400 deg. fahr. Although some installations have attempted to use higher temperatures, it has been found that the stoker maintenance has been adversely affected.

The installation of large turbo generators has continued although no units have been projected larger than those mentioned in the last report. The largest machines now on order are two 160,000-kw. units for the Hudson Avenue plant of the Brooklyn Edison Company. It is noteworthy that all of the turbo generators except one, that are now on order in sizes greater than 100,000 kilowatts, are of the tandem compound type. The exception is the 110,000-kw. high-pressure vertical-compound machine for the Ford Motor Company. The development of generators of large capacity was an essential to the use of tandem-compound turbines.

The record in capacity for single cylinder turbines operating at 1,800 rev. per min. is now carried by two 80,000-kw. turbo generators in the Charles R. Huntley station of the Buffalo General Electric Company. Steam supply to these units is at 435 lb. and 750 deg. fahr.

In the field of high-speed turbo generators, single cylinder condensing units are now in operation in the United States up to 10,000-kw. at 3,600 r. p. m., and tandem-compound units at the same speed up to 15,000 kw. A 15,000-kw. single-cylinder condensing unit of English manufacture has recently been installed in Canada and the C. A. Parsons & Company are willing to build single-cylinder units of 25,000-kw. capacity to operate at 3,600 r. p. m.

Intensive study in turbine design is being made in connection with the use of higher steam temperatures. This problem as well as that of blade erosion is a matter of metallurgy, and the developments to date indicate that it will soon be possible to operate turbines at initial steam pressures above 500 lb. without the necessity of reheating. At the present time a 60,000-kw. unit has been built to use steam at 650 lb. and 825 deg. fahr., and illustrates the simplification and turbine arrangements that will be possible when higher steam temperatures are available.

High-Voltage Generators

There has been a significant demand for generator units of larger and larger capacities, and while this has possibly been the condition since the beginning of power station construction it appears to advance by periods with the most recent one occurring within the past five years. With an increase in generator capacity the designing engineers have been faced with the problem of providing suitable and reliable insulation, conductors, supports, and terminals both internal and external to the machines. Machines of larger capacity for a given voltage mean greater currents. Greater currents mean larger conductors, and consequently greater weights to support normally and greater stresses to provide for at times of short circuits. With the greater currents other external difficulties also arise, such as the provision for the installation of large cables if the power is taken away in underground cables, the reduced carrying capacity of the cables if many are required in restricted spaces, and the provisions necessary to nullify the effect of the sheath voltages. Consequently there has been a very natural trend to higher generator voltage and to multiple-winding machines to reduce the amount of current per conductor.

Unless it is necessary to consider generation at a pre-established voltage and the distribution problems connected therewith, in other words, if generation alone, is to be considered, the most economical voltage usually increases slightly with the increase in the size of the unit. From the generator manufacturer's standpoint, for generators of 100,000 kw. or more, voltages in the neighborhood of 16,000 to 18,000 volts are reported to result in the most economical design. In some instances, economics dictate machines within this range of voltage with transformers for stepping up to the desired transmission voltage, so that, where the generator voltages are not well established, it might be said that for machines above 100,000 kw., the present trend is toward the use of multiple-winding machines with transformers or auto-transformers, rather than to higher voltage machines. The trend will no doubt continue toward multiple-winding machines until the point in capacity is reached when it will prove more economical to increase the voltage.

Some attempts have been made to standardize on generator voltages above 13,800 volts, but since the introduction of successful multiple-winding machines, the study and demand for higher standard voltages has not been so insistent, and may be said to be dormant for the time being. In other words, the double-winding design has made it possible to increase the capacity without increasing the voltage, and to postpone the day when it will be necessary to go to higher voltage. It is not at all unlikely that in the future, generators will be built with more than two windings. The principal difficulty with more than one winding, is in finding sufficient space at the terminals of the machine windings, to install potheads and make connections with satisfactory clearances.

Within the past three years there have been installed in the territory adjacent to Chicago, and there are now in operation, seven 22,000-volt generators with a combined generating capacity of 474,000 kw., ranging in size from 52,500 kw. to 105,000 kw. Additional 22,000-volt generators totaling 432,000 kw., and one 18,000 volt, 115,000-kw. generator are on order for this territory, to be installed during the years 1931-1932.

Outside of the above there have been but four steam-driven generators placed on order or installed recently in this country for voltage ratings above 13,800 volts, namely:

Two 160,000-kw., 16,500-volt units for the Brooklyn Edison Co., and

Two 94,000-kw., 16,500-volt units for the Southern California Edison Company.

Abroad, the outstanding recent high-voltage installations which will be watched with considerable interest are the two 33,000-volt, 25,000-kw., 3,000-r. p. m. generators at Brimsdown, England, and the 36,000-volt, 25,000-kw., 3,000-r. p. m. generator at Langerbrugge, Belgium.

Switch Structures, Switching, and Control

The housing of major switching in both congested and open localities is receiving much study, particularly new installations, because of the advent of metal-clad switchgear. There has been a marked increase in and trend toward the use of metal-clad switchgear in place of indoor cell type and outdoor open type bus structures. Many hundred indoor and outdoor type metal-clad combined switch and bus units of American design are now in service, some with air and some with oil-filled metal enclosed bus compartments.

The first installation in this country, and possibly in the world, of high-voltage outdoor metal-clad switchgear was the 33-kv. substation of the Public Service Company of Northern Illinois, at Wheaton, Illinois. This has been in service since March 1928. Since then there have been many other installations which embody improvements in design and manufacture. This type of switchgear can now be obtained in practically all capacities for which circuit breakers have been developed, including 132 kv. One 132-kv. installation is now being made. The earlier large units involved a considerable amount of field assembly. The latest designs permit complete factory assembly and testing of very large capacity units, such as a full double bus section for one circuit, complete with instrument transformers, buses, etc., for breakers of 22-kv., 3,000-amperes, 2,500,000-kva. interrupting capacity. These units are shipped completely assembled and oil filled thereby entailing a minimum of field assembly and installation work, and avoiding the necessity of drying out, reconditioning, etc., by purchaser.

In the case of several generating stations it has been found that an outdoor oil-filled metal-clad switchgear structure could be installed cheaper than an isolated or separated phase indoor cell structure if the cost of the building is taken into consideration; in some cases a saving as high as 20 per cent has been indicated. Other companies report the reverse where installation conditions are different. One company has proved by actual cost data that for 33-kv. substations the total over-all cost of metal-clad outdoor switchgear erected and ready for service, compares favorably with that of the conventional open type formerly used. This latter comparison, however, would not yet hold for all conditions and localities.

Additional advantages to be gained from complete factory built equipment are the saving in space, the salvage value in case of replacement or rearrangement, and the much greater safeguards to operators and service.

There is a growing demand for faster operation of circuit breakers in case of fault. The manufacturers have made considerable progress toward meeting this condition in the design of circuit breaker operating mechanisms and contacts and methods of extinguishing the arc as well as in the high-speed relay designs. Tests have shown repeated operations where the arcing time was as low as one to two cycles. Large breakers are now available with a conservative over-all time rating of eight cycles. In view of these developments it is quite possible a more severe duty cycle than the 2-OCO may be considered for the rating of oil circuit breakers.

The interest indicated in locating equipment outdoors is not confined entirely to switchgear. There are a few instances where large rotating units have been installed outdoors, and the subject is being given much study.

There has been an increase in the tendency toward the use of steel switchboard panels and the use of hinged panels or cubicals. The desirability of smaller switchboards in the larger power stations and substations is also receiving attention. Various attempts have been made to use miniature equipment, and a smaller number of items, and combination units of instruments and relays. At the same time there is a growing demand for more relays and instruments for one purpose or another. The supervisory system of control seems to be arousing more and more interest as a means of condensing or consolidating the control of a large number of circuits within the convenient reach of a single operator.

The so-called distance relays are becoming more popular. The automatic synchronizing, automatic frequency, and automatic load division control are receiving more attention. Although the first has been available for a number of years, the latter are more recent developments and it is quite possible that the demand for both may grow.

If the predictions indicated in recent announcements with reference to vacuum tube developments, such as the "thyratron," may be anticipated, we are about to see some very wonderful and radical changes in the entire scheme of station control, switching, transformation, transmission and control station design in general. To what extent and how rapidly this may take place is at present problematical. The possibilities we must admit, however, are tremendous. Already there have been some novel commercial applications and very promising laboratory tests extending over a considerable period.

A new type of adjustable-speed control for a-c. motor drive is now available, permitting practically a straight line speed curve with infinitely small steps from zero to maximum. The drive can be installed at nearly the same cost as the drives previously used. The method of control permits high efficiency which in some cases shows a considerable saving over any other type of control. The drive will maintain constant speed regardless of load, is simple, permits the use of standard electrical design features, and to a considerable extent, standard machine parts. To date the service applications have been confined to boiler draft fans and boiler feed pumps, but the drive is adaptable to many other services where fine speed adjustments, and simplicity of operation with high efficiency, are important factors. Thirty-five of these equipments were ordered in 1930, some of which have now been in service for several months. For those who are not familiar with the "Rossman Drive" system it may be of interest to state it consists primarily of an induction motor of standard design, except that the mechanical construction is modified to permit what would be the stator to revolve. This revolving stator is connected by texrope or other means, to a smaller standard d-c. machine fed from a standard motor-generator set or other d-c. source. The speed of the small d-c. machine is controlled by adjusting the voltage impressed on its armature by the generator of the motor-generator set. This may or may not be supplemented by field control. By varying the speed and direction of rotation of the d-c. machine, the load may be driven at any speed within the design range.

Factors at Present Affecting Hydroelectric Development

The increasing attention directed to the large-scale hydro developments on the Colorado and St. Lawrence rivers by governmental agencies is perhaps a new factor influencing the trend of hydroelectric installations. At the same time the federal waterpower licensing policies are being questioned and subject to criticism by both private and political interests, and both have been coincident with severe drought during the past two years in many parts of the country. The complementary value of hydro and steam power sources on systems supplied mainly by hydro has been fully realized, and the principal hydroelectric systems on the Pacific Coast, in the southeastern states, in New England, and in the vicinity of Niagara Falls, have either put into operation during the last two years steam plants of large ultimate capacity or have affected large capacity ties with existing steam plants in adjacent territory. The recent availability of low cost gas and oil fuels in the West, and the advances made in the thermal efficiency of large boilers and turbines, combined with their attractive investment costs, are causing a pronounced predominance there of steam-electric installations that will continue for an unknown period. In the East and South the necessity of steam reserves for low-flow periods has accelerated steam expansion programs. At Niagara the entire water diversion permitted under the existing treaty is utilized and the load growth necessarily must be assumed by steam generation.

Type of Steam Plants on Hydroelectric Systems

A marked similarity in certain design features is noticeable in all of the new steam plants supplementing power systems hitherto dependent upon hydro generation. Gas and oil are the outstanding fuels in the West, while in the East pulverized coal exclusively is fired. Boiler capacities range from 400,000 to 550,000 lb. of steam per hr. at pressures between 425 to 475 lb. per sq. in. with the exception of one plant on the Pacific Coast operating at 1,300 lb. per sq. in. Turbine capacities vary from 40,000 kw. up to 100,000 kw., and one to three boilers are installed per turbine, the usual number being two. The selection of pulverized coal firing appears to be made for reasons other than the emergency starting of boilers; and in fact extra facilities for standby operation of turbines and boilers are provided in only one of the recent plants, which operates on a system where steam generation will be a minimum yet service demands require continuous availability of the steam-electric generator.

General Features of Recent Hydroelectric Development

No hydroelectric plants of unusual total capacities have been put into operation during the past two years, although there have been one or two new records for turbines of large physical dimensions, and the three 49,000-hp. Francis units in the Waterville plant in North Carolina surpass in capacity all previous units of that type operating under high heads. An unusual construction procedure was adopted for the Chute-a-Caron plant on the Saguenay River in Canada. The preliminary drawings for the Boulder Dam plant on the Colorado River reveal no unusual features except the height of the dam and the contemplated power capacity. The Spier Falls plant on the Hudson River is an interesting example of rehabilitation and design investigation by means of model tests. In fact the increasing use of model testing, and its application to the design of the propeller type turbine wheel, constitute the outstanding technical advance in this country in hydroelectric practise during the past two years.

Propeller Turbine Development and Model Testing

Notable installations of propeller turbines of the fixed and manually adjustable blade types were in operation or approaching completion in 1928, and one small capacity wheel of the automatically adjustable type, the Kaplan turbine, was in the course of erection. Since 1928 there have been numerous installations in America of small capacity Kaplan type propeller turbines, that have been designed and installed under European licenses. The Kaplan turbine was first developed in Europe where there are now some large capacity wheels in operation. It is essentially suitable for low-head developments, being used for heads up to about 70 ft. European designs of the fixed blade and Kaplan turbines have been based upon extensive model testing of the turbine wheels as well as of the associated inlet casings and draft tubes.

One of the principal objects of testing models of propeller type wheels has been to determine the limiting conditions of cavitation, for which adjustable draft head conditions are required in the test laboratory. Cavitation, or the formation of bubbles of vapor and air in low-pressure areas adjacent to the runner surfaces, causes a drop of wheel efficiency, but its most prominent effect is the rapid disintegration of the runner material. Cavitation pitting had been encountered in this country with Francis type wheels under certain conditions of specific speed and draft head, and an amount of field experience has been accumulated by which proper operating conditions can be selected for Francis wheel installations. One of the chief advantages of the propeller turbine is the higher specific speed that is possible, but as field data were lacking for such operation, it was considered essential in Europe to determine the optimum installation conditions in advance of construction by means of cavitation testing. Following such investigations propeller turbines of record dimensions, horsepower, and water discharge capacity have recently been installed in the Ryborg-Schworstadt and Kembs plants on the Rhine River in Europe. Pertinent data about these plants are as follows:

Plant	Ryborg-Schworstadt	Kembs
Type of runner	Kaplan	Fixed blade propeller
Number of units	4	5
Head in feet	35	54
Turbine rating-horsepower	35,000	36,000
Water discharge-cu. ft. per sec	10,500	6,800
Rev. per min	75	94
Runner diameter-inches	276	220.8

Cavitation laboratories have been built during the past year, one or two in the United States and one in Canada, for the investigation of design problems concerning propeller type wheels. The construction of a national Federal hydraulic laboratory has also been recently authorized; model testing has been done extensively at one of the technical colleges in the United States for the design of dam spillways, water courses, and turbine settings, and two or three other colleges and individual companies have done a certain amount of such investigation. The first large plant in this country to install automatically adjustable blade propeller turbines is now being built at Safe Harbor on the Susquehanna River in accordance with data obtained from cavitation and wheel setting tests. Six turbines having a rating of 42,500 hp. each at a gross head of 55 ft. are being installed initially. The wheels will have a diameter of 220 in., a water discharge of 8,000 cu. ft. per sec. at rated head and output, and will operate at 109.1 rev. per min.

Briefly described the Kaplan turbine consists of a propeller, or axial flow turbine, whose blade angle is controlled by the speed responsive governor that controls the turbine wicket gates. Separate servo-motors are provided for operating the blades and gates, and a cam is used in the governing mechanism to direct the movement of the runner blades according to the movement or position of the wicket gates. The servo-motor for operating the runner blades forms part of the turbine shaft, and is usually located just under the generator coupling. The links and crank arms for moving the blades are enclosed in the runner hub.

By automatically maintaining the correct relation of blade position to gate opening, the peak efficiencies of a series of propeller wheels each having the proper blade angle for a particular turbine load, are secured, with the result that the efficiency-horsepower curve of such a turbine is quite flat compared to similar curves for fixed blade propeller and Francis turbines, the efficiency at low loads being materially higher. Another feature of the Kaplan turbine is the overload capacity possible by adjustment of the blades, which is of particular value in times of reduced head during high river stages. It is expected that the efficiency of the Safe Harbor turbines will exceed 85 per cent over two-thirds of the load range, and to equal 90 per cent or better for the third quarter of the unit capacity.

Rehabilitation of Hydro Developments

The 57,000-hp. unit recently added to the Spier Falls plant on the Hudson River, New York, exemplifies two distinct tendencies in hydroelectric practise, illustrating in addition to the use of model testing as a design adjunct, the recognition of the value of an over-developed plant for supplying peak-load capacity and the benefit derived from a storage resource by a run-of-river development. At full load the wheel discharge is 7,000 cu. ft. per sec., making it the largest Francis-type runner to date in this respect as well as in physical dimensions. The minimum regulated flow of the Hudson River at Spier Falls is 3,000 sec.-ft., and 5,000 sec.-ft. for 50 per cent of the time. Both the turbine and generator approach record sizes in physical dimensions, the total weight of the rotating element being about 450 tons. The generator stator is 37 ft. in diameter, and the diameter of the scroll-case entrance of the turbine is 26 ft. The unit operates at a speed of 81.8 rev. per min. under a head of 81 ft. Tests of a model of the forebay and intake structures enabled the best forebay outline to be determined with regard to amount of necessary excavation balanced against the head loss in forebay and intakes. The tests revealed that the area of the intake gates could be economically reduced 20 per cent, and this was of special value because the water passages are so large that they gave rise to structural design difficulties. It is reported that the tests resulted in a saving equal to ten times the cost of the tests.

High Head Plants

The Waterville plant of the Carolina Power and Light Company on the Pigeon River in North Carolina has an unusually high operating head, 840 to 750 ft., for a hydro plant in the eastern part of this country. There are three 49,000-hp. reaction wheels in the plant, operating at 400 rev. per min. and these are of record note for their capacity at such a head. The six-mile tunnel from the reservoir created by the dam to the power house is unprecedented even in the notable high head installations on the Pacific Coast. The use of cast steel butterfly valves of 9 ft. diameter under a total head of 840 ft. located in the penstocks near the power house, has been reported quite successful, and is an advance in the size of such valves under high pressure. Johnson valves are also provided in the penstocks where they enter the plant.

The record for large capacity high head Francis wheels will shortly be established in the Diablo plant of the City of Seattle, where two turbines of 90,700-hp. capacity each, to operate under a head of 327 ft. are being installed. The turbines will have cast steel scroll cases and concrete elbow draft tubes.

The record head, however, for Francis wheels occurs in a European plant, the Bringhausen plant in Germany, where four 40,500-hp. horizontal-shaft Francis turbines are being installed to operate under a head of from 950 to 1,000 ft. This is a pumped storage development mentioned later.

Large Scale Hydro Developments

The Beauharnois development on the St. Lawrence River in Canada is notable for the ultimate capacity being planned when the entire flow of the river passes to the power house through the combined navigation and power canal connecting two of the lakes on the flow line of the river. The initial section of the plant will contain ten 50,000-hp. units, to operate under a head of 83 ft. The final capacity will be 2,000,000 horsepower. The construction of the canal between lakes St. Francis and St. Louis, which will be 15 miles in length with a width of 3,000 ft. and a depth of 27 ft. is outstanding because of its magnitude rather than any engineering difficulties.

Another plant that illustrates the scale of development possible on some of the rivers in Canada is the Chute-a-Caron plant on the Saguenay River where four 65,000-hp. units have been installed as the initial step of the future Shipshaw plant of 1,000,000 horsepower. The Chute-a-Caron dam will serve to divert the river for later construction of the Shipshaw plant, but because the head at Chute-a-Caron is only 151 ft. as contrasted to that of 205 ft. at the parallel site, the Chute-a-Caron plant will be operated in the future only during river flows sufficient to supply both plants. The difficulty of construction in the gorge of the Saguenay River is thus being solved by the step-by-step development at the two neighboring plant locations. The river was diverted in a unique manner for the construction of the Chute-a-Caron dam by toppling a concrete cofferdam 92 ft. long into the swiftly flowing current, which caused the flow to pass into an artificial channel previously prepared. The action of the concrete monolith weighing 11,500 tons was accurately predicted by means of model tests.

Storage Developments

The largest hydroelectric plant in New England has been recently completed at Fifteen Mile Falls on the upper reaches of the Connecticut River, in conjunction with the first 220-kv. transmission line in New England. The plant is designed for four 53,000-hp. units at 175-ft. head, and is the first development at two nearby sites which will eventually have a total combined rating of 300,000 horsepower. The completion of the second plant will create a reservoir for regulating the river flow not only for the plants at Fifteen Mile Falls, but also for the plants at Bellows Falls and Vernon, farther down the river. The 220-kv. line carries the output of the plant to a distributing point in the vicinity of Boston.

The Osage plant at Bagnell, Missouri, now approaching completion, will contain six 33,500-hp. units operating under an average head of 90 ft. Without storage this plant would not be feasible since the river flow varies from 324 to 110,000 cu. ft. per sec. with an average of 10,500 sec-ft. The dam will create a reservoir 95 sq. mi. in area having an impounded volume of 87 billion cu. ft., so that the flow of the river will be completely equalized with a draw-down of 30 feet. The average yearly energy available will be about 400 million kw-hr. The Osage plant is also a late example of the omission of a superstructure over the generator bay, the station crane having one gantry leg while the other end of the crane rests on top of the outer wall of the electrical bay which is placed over the penstocks between the dam bulkhead and the generator bay. Low metal housings are provided over the tops of the generators.

The Saluda storage development in South Carolina, described in the last report, was placed in operation last year and is notable for its reservoir capacity of 102 billion cu. ft.

Outdoor Type Plants

The omission of the generator room superstructure continues both for small plants of a single unit and for plants of large installed capacity. Generator designers are predicting that the flexibility of design now possible with fabricated construction, and the latitude permissible in the layout of auxiliary power and excitation systems, will lead to the arrangement of generators to conform to the design of the power house, and that the logical outcome may be the wider use of outdoor generator designs.

Pumped Storage Plants

No installations of pumped storage plants in America have followed the completion of the Rocky River plant in Connecticut, although the use of pumped storage continues popular in Europe where electric system peaks are of shorter duration than in this country. One illustration is the Bringhausen plant on the Weser River in Germany, now under construction, which will contain four combination pump and waterwheel units, each consisting of a 40,500-hp. Francis type horizontal turbine coupled directly to a 36,000-kva. generator, on the other side of which is a clutch for coupling to a 100,000-gal. per min. pump requiring 29,000 hp. for pumping. The plant is connected to an upper reservoir at an elevation 1,000 ft. higher by two penstocks 3,250 ft. in length. The water to be pumped to the reservoir amounts to 26,800,000 cu. ft., from which 500,000 kw-hr. will be generated. Power for pumping during off-peak hours is obtained from interconnected steam plants and other hydro plants on the system.

The horizontal coupling of a pump and a turbine with a generator and/or motor seems to be the preferred arrangement for pumping plants in Europe, and is in contrast to the Rocky River plant layout of pumping units with individual drive motors separate from the main turbine and generator, all of the equipment being of vertical type. The Rocky River pumps which are the largest high-head pumps in this country, have a volute discharge casing without diffusion vanes, and are of the single inlet type. On test the Rocky River pumps showed a maximum efficiency of 91.7 per cent; the efficiency expected by the designers of the German pumps is approximately 80 per cent.

Hydroelectric Generator Developments

There has been a widespread adoption during the past two years of fabricated steel plate construction of both stator and rotor of vertical waterwheel generators, in place of the use of castings formerly standard. Such generator construction of welded steel plate is lighter in weight, is considered to be more reliable mechanically, and is more adaptable to design arrangements. There has been an increased use of the umbrella, or overhung type of generator rotor, in which by means of downwardly curved rotor arms the centerline of the rotor rim or pole faces is brought below the horizontal centerline of the hub. By locating a combined guide and thrust bearing, sometimes of the spherical type, just below the rotor hub, a very material reduction in over-all generator height is secured. The use of rolled steel plates and fabricated construction for the stator has also facilitated the arrangement of ventilating ductwork in connection with the water tube air coolers that are now used very largely for generator cooling. Other advantages of fabricated plate construction are quicker manufacture and possibility of design for shipment without restriction by permissible weights or clearances.

Acknowledgments

This report has been compiled by a subcommittee, the members of which respectively prepared the several sections as follows:

F. A. Allner, Hydroelectric Topics; N. E. Funk, Major Influences in Current Design of Steam-Electric Plants, and Factors at Present Determining Maximum Size of Boilers and Turbines; F. H. Hollister, Rehabilitation of Existing Steam Plants, High-Voltage Generators, Switch Structures, Switching, and Control; H. W. Leitch, Reduction in Operating Costs of Steam-Electric Plants, and Technical Developments in Steam-Electric Plant Design.

The subcommittee wishes to express its appreciation of the helpful suggestions received from the main body of the Power Generation Committee.

Bibliography

The following list includes, of the vast literature produced on the subject of Power Generation in the last two years, only such salient articles and reports as describe or explain the newer developments and broader trends in the mechanical design of power plants. References to machinery details may be found in the comprehensive Engineering Index Service in the Engineering Societies Library, New York.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Reviews prepared by Professional Divisions

Progress in Fuel Utilization in 1929 and 1930..........................FSP*-Vol. 52, No. 1-1 and Vol. 53, No. 1

Progress in Hydraulics (1929) and (1930)..........................HYD†-Vol. 52, No. 32-11 and Vol. 53, No. 1

*Fuels and Steam Power Division.

†Hydraulic Division.

Progress in Steam Power Engineering (1929) and (1930)................FSP-Vol. 52, No. 1-2 and Vol. 53, No. 1

Report of Committee on Survey of
Hydraulic Research.............HYD-Vol. 52, No. 14-5
Research Committee on Boiler Feed-
water Studies...................Vol. 51, No. 12-22

Articles

Allen, R. C., "Commercial Problems in Steam-Turbine Design" FSP Vol. 51, No. 1-14.

Clark, F. S., "Effect of Large Boilers at High Capacities on Operating Characteristics and Investment in Boiler Plants" FSP Vol. 52, No. 27-31.

Cushing, H. M., "Evolution of the Slag-Tap Furnace at the Charles R. Huntley Station of the Buffalo General Electric Company" FSP Vol. 51, No. 22-39.

Frisch, Martin, "Relative Economy of Pulverized Coal, Oil, and Gas as Boiler-Plant Fuels" FSP Vol. 52, No. 1-10.

Grunert, A. E., "Comparative Performance of a Pulverized-Coal-Fired Boiler Using Bin System and Unit System of Firing," FSP Vol. 53, No. 1-4.

Hirshfeld, C. F. and G. U. Moran, "Modern Stoker Equipment" FSP Vol. 51, No. 1-20.

Hirshfeld, C. F. and G. U. Moran, "The Performance of Modern Steam-Generating Units" FSP Vol. 52, No. 27-34.

Jowett, Edwin, "High Pressure Turbine Installation of Kansas City Power and Light Company" FSP Vol. 51, No. 1-18.

Kreisinger, Henry, "The Bin System of Pulverized Coal" FSP Vol. 52, No. 27-36.

London, W. J. A., "Coal Pulverizers" FSP Vol. 51, No. 12-28.

Martin, C. R., "Increased Kilowatt Output of Adjustable Blade Propeller" HYD Vol. 52, No. 6-1.

Savage, H. D., "Recent Developments in Stoker Design" FSP Vol. 52, No. 12-18.

Sherman, Ralph A., P. Nichols, and Edmund Taylor, "Study of Some Factors in Removal of Ash as Molten Slag From Powdered-Coal Furnaces" FSP Vol. 51, No. 22-51.

Sims, W. F., "Trends in Development of Electricity-Supply Systems" FSP Vol. 51, No. 1-10.

Smith, B. F., "The Kaplan Adjustable-Blade Turbine" HYD Vol. 52, No. 30-8.

Tefft, Wm. W., "Power-Steam or Hydro, or Both," HYD Vol. 52, No. 14-6.

Van Leer, Blake, R., "Some Interesting European Hydraulic Turbine Research" HYD Vol. 51, No. 6-6.

White, A. E., "Metals Used in Power Plants" FSP Vol. 51, No. 1-5.

Serial Reports of the Engineering National Section, National Electric Light Association

"Boilers, Superheaters and Economizers," Pubs. 289-75 and 081. Contains detailed bibliography.

"Condensing Equipment," Pubs. 289-111 and 069. Contains bibliography.

"Foreign Developments," Pubs. 289-64 and 042. Contains bibliography.

"Higher Steam Pressures and Temperatures," Pubs. 289-73 and 053. Bibliography.

"Hydroelectric Bibliography and Manufacturers Statements," Pubs. 289-86 and 086.

"Power Station Betterment," Pub. 044.

"Pulverized Fuel," Pubs. 06 and 12. Contains explanatory bibliography.

"Stoker Equipment and Furnaces," Pubs. 289-71 and 068. Contains bibliography.

"Turbines," Pubs. 289-98 and 078. Contains bibliography.

Articles in Technical Periodicals

Allen, E. G., "Shuffleton Steam Power Plant, Renton, Washington," *Power Plant Engineering*, Vol. 34, pp. 1148-55, Oct. 15, 1930.

Allen, E. G., "River Bend Turbines Have New Design Features," *Electric Journal*, Vol. 27, pp. 69-71, Feb. 1930.

Annett, F. A., "Alden Hydraulic Laboratory; Workshop of Modern Research," *Power*, Vol. 72, pp. 418-22, Sept. 9, 1930.

Avery, C. L., "Model Testing—A Phase of Design," N. E. L. A. *Bulletin* 17, pp. 765-9, Dec. 30, 1930.

Bailey, A. D., "Trends in Steam Generating Equipment," *Power Plant Engineering*, Vol. 34, pp. 1390-3, Dec. 15, 1930.

Baumann, K., "Some Considerations Affecting Future Developments of the Steam Cycle," *Engineering*, Vol. 130, pp. 597-9, 661-4, 723-7, Nov. 7, 21, and Dec. 5, 1930.

Caldwell, W. E., "Hell Gate Station Design," *Electrical World*, Vol. 95, pp. 444-50, 500-4, March 1-8, 1930.

Clark, F. S., "Steam Pressure and Temperature; Power Plant Progress Review," *Power*, Vol. 70, pp. 932-5, Dec. 10, 1929.

Clogher, A. C., "Waterville Hydro Makes Possible Notable Interconnection," *Electrical World*, Vol. 96, pp. 380, 384-9, August 30, 1930.

Dyer, W. E. S., "Why 1,800-lb. Pressure was Selected for the Philip Carey Plant," *Power*, Vol. 71, p. 448, March 18, 1930.

Electrical West, "Second 100,000-Kw. Long Beach Unit Differs Slightly; Southern California Edison Company," Vol. 65, p. 288-9, Dec. 1930.

Electrician, "Power Stations in 1930," Vol. 106, p. 58-61, January 9, 1931.

Electric Journal, "New Stoker Feeds Coal at 22 Tons per Hour," Vol. 28, p. 7, January 1931.

Electric Journal, "Rating of 3,600-r. p. m. Turbine Generators is Steadily Increasing," Vol. 28, p. 8-9, January 1931.

Engineer, "Construction and Operation of Large Power Plants; discussion at World Power Conference," Vol. 150, p. 14-15, July 4, 1930.

Engineer, "High Pressure Extensions to the Issy-les-Moulineaux Power Station," Vol. 149, p. 178-180, February 14, 1930.

Engineer, "Ladd Boiler, East River Power Station, New York," Vol. 149, p. 140-1, January 31, 1930.

Engineer, "Two-Fluid Cycles for Power Plants; Koenemann Process," Vol. 150, p. 458, October 24, 1930.

Engineer, "62,500-Kva. Turbo Generators at the Goldenberg Power Station, Germany," Vol. 150, p. 144-5, 148, August 8, 1930.

Engineering, "Hams Hall Generating Station of the Birmingham Corporation," Vol. 128, p. 545-7, 663-6, 759-60, 793-6, 829-36, November 1, 22, December 13, 27, 1929.

Engineering News-Record, "Power Development on Saguenay River Begun at Chute-a-Caron," Vol. 103, p. 889-95, December 5, 1929.

Fox, H. K., "Semi-automatic Hydro Plant Utilizes Variable Flow; Merced Falls Plant of the San Joaquin Light & Power Corporation," *Electrical World*, Vol. 96, p. 991-3, November 29, 1930.

Gallalee, J. M. and Ferrill, R. M., "Gorgas Expands in Separate Plant," *Electrical World*, Vol. 95, p. 732-7, 837-9, April 12, 26, 1930.

Gilbert, E. M., "Gilbert Operating Experiences," *Electrical World*, Vol. 96, p. 1044-5, Vol. 97, p. 100-2, Dec. 6, 1930, Jan. 10, 1931.

Gleichmann, H., "Recent Developments of the Benson Boiler," *Power Plant Engineering*, Vol. 34, p. 612-13, June 1, 1930.

Hammond, W. P. and Oliver, J. M., "Atkinson Steam Plant Supplements Atlanta System," *Power*, Vol. 72, p. 604-8, Oct. 14, 1930.

Hirshfeld, C. F., "Trends in Power Development in the United States and Europe," *Mechanical Engineering*, Vol. 51, p. 727-35, Oct. 1930.

Hogan, J. P., "Record Hydro-Electric Turbine Installation—Spier Falls Plant on the Hudson River Enlarged," *Civil Engineering*, Vol. 1, p. 519-23, March 1931.

Hogg, T. H., "Trends in Water Power Development," *Canadian Engineer*, Vol. 59, p. 123-30, July 8, 1930.

Institute Mechanical Engineers Proceeding, "Operating Results with the Recent Extensions at Barton Power Station," Vol. 3, p. 603-54, 1930.

Irwin, K. M., "Deepwater Operating Experiences," *Electrical World*, Vol. 96, p. 1045-7, 1171-2, Dec. 6, 27, 1930.

Karpov, A. V., "European Low Head Hydroelectric Developments; Ryborg-Schworstadt and Kembs Plants," *Power*, Vol. 71, p. 515-17, Apr. 1, 1930.

Kehoe, A. H., "Trends in Engineering Costs; their Causes and Remedies," *Electrical World*, Vol. 95, p. 1258-62, June 21, 1930.

Kerr, S. L., "Frequency and Load Control on Electric Systems," *Power Plant Engineering*, Vol. 34, p. 682-5, June 15, 1930.

Knodel, H., "1,000-Hour Trial on a 1,700-Lb. Loeffler Boiler," *Engineering*, Vol. 130, p. 632-4, Nov. 14, 1930.

Lee, C. J. and Blackman, H. N., "1930—Notable Year for Water Power Development," *Electric Journal*, Vol. 28, p. 5-6, Jan. 1931.

Lewis, F. B., "Hydro Yields to Steam on Economic Grounds," *Electrical World*, Vol. 95, p. 1298-9, June 21, 1930.

Liston, J., "Developments in the Electrical Industry During 1930," *General Electric Review*, Vol. 34, p. 6-9, January 1931.

Markwart, A. H., "Cheap Steam Power Checks Hydro Expansion," *Electrical World*, Vol. 95, p. 1271-3, June 21, 1930.

Markwart, A. H., "Mokelumne Project to Develop 170,000 Horsepower," *Power*, Vol. 71, p. 842-6, May 27, 1930.

Markwart, A. H., "Station A—San Francisco's New 1,400-Lb. Steam Plant," *Power Plant Engineering*, Vol. 34, p. 664-71, June 15, 1930.

Nash, F. M., "Automatic Operator a Success; Norwood Hydroelectric Plant," *Electrical World*, Vol. 96, p. 342-6, August 23, 1930.

Newbury, F. D., "Electric Power Plant Equipment and Practise in America," *Electric Journal*, Vol. 26, p. 500-4, November 1929.

Orrok, G. A., "High Pressure and Temperature in Power Generation," *Engineering*, Vol. 129, p. 299, February 28, 1930.

Philo, F. G., "Comparative Performance of a Large Boiler Using Oil and Natural Gas Fuels," *Power*, Vol. 71, p. 956, June 17, 1930.

Powell, C. A., "Developments in 1930 by Westinghouse," N. E. L. A. *Bulletin*, Vol. 18, p. 10-12, January 1931.

Power, "Ford Installing World's Largest High Pressure Unit in Rouge Plant," Vol. 70, p. 994-7, Dec. 24, 1929.

Power, "Old and New Steam Generating Units Present Striking Contrast," Vol. 71, p. 609, April 15, 1930.

Power, "Raritan River Plant Combines Efficiency with Low Investment Cost," Vol. 73, p. 94-9, January 20, 1931.

Power, "Trends in Steam Prime Movers," Vol. 73, p. 11-14, January 6, 1931.

Power Plant Engineering, "Ashtabula Adds 150,000 Kw. to Cleveland Electric System," Vol. 35, p. 122-9, January 15, 1931.

Power Plant Engineering, "Engineering Developments in the Power Industry During 1930," Vol. 34, p. 1387-9, Dec. 15, 1930.

Power Plant Engineering, "James H. Reed Station will Help Duquesne Light Company Serve Pittsburgh District," Vol. 34, p. 366-73, April 1, 1930.

Power Plant Engineering, "New Boilers and Generating Units for Hudson Avenue Generating Station," Vol. 34, p. 1018-19, September 1, 1930.

Power Plant Engineering, "South Amboy—It's Different; Jersey Central Power & Light Company," Vol. 34, p. 788-99, July 15, 1930.

Power Plant Engineering, "Trends of the Year in the Boiler Room," Vol. 34, p. 1395-1401, Dec. 15, 1930.

Roberts, J. F., "Adjustable Blade Runners Increase Back River Hydro Plant Output," *Power*, Vol. 70, p. 792-5, November 19, 1929.

Robinson, E. L., "General Trend of Steam Turbine Development by the General Electric Company," *General Electric Review*, Vol. 32, p. 638-43, November 1929.

Rochel, K., "Loeffler vs. Schmidt—Hartmann," *Power*, Vol. 71, p. 718-19, May 6, 1930.

Science, "Claude Ocean Power Plant," Vol. 72, Supplement 10, July 11, October 10, 1930.

Thompson, P. W., "New Stations vs. Rebuilding; Delray No. 3 Built on Site of Existing Station," *Electrical World*, Vol. 94, p. 1067-9, November 30, 1929.

Turner, C. S., "Delray Boilers Depart from Previous Practice," *Power*, Vol. 71, p. 500-3, April 1, 1930.

Warren, G. B., "Recent and Possible Future Developments Affecting the Economics of Large Steam Turbine Practice in the United States," *General Electric Review*, Vol. 33, p. 434-43, 522-7, August, September, 1930.

Weisselberg, A., "Experience with High-Pressure Boilers in Central Europe," *Power*, Vol. 72, p. 600-3, October 14, 1930.

Whiton, H. S., "Advancement in Turbine Room Practice," *Power Plant Engineering*, Vol. 34, p. 1404-6, December 15, 1930.

Williamson, G. V., "New Furnaces and Pulverizers at Cahokia," *Power Plant Engineering*, Vol. 34, p. 267-8, March 1, 1930.

Wilson, T., "Lakeside's Second High-Pressure Unit," *Power* Vol. 71, p. 618-21, April 22, 1930.

Power Transmission and Distribution

ANNUAL REPORT OF COMMITTEE ON POWER TRANSMISSION AND DISTRIBUTION[*]

THE Committee has continued with its work during the past year through a number of subcommittees organized as in preceding years. All of these subcommittees have been very active in studying the problems in their respective fields, and in promoting investigation work and the preparation of papers for presentation before the Institute. The reports of the work of the several subcommittees follow.

SUBCOMMITTEE ON DISTRIBUTION

One of the most interesting developments in connection with the distribution of electrical energy during the past year has been the practical application of the network principle to primary distribution. The economies and improvements to service which are made possible through the adoption of the low-voltage network have been so clearly demonstrated by the generally satisfactory performance of the many recent installations, that a wider application of the principle is not surprising.

At the present time there is being installed a 4-kv. primary network in Pittsburgh, Pa. This will serve a residential district of comparatively low-load density which was previously served by an overhead radial system.

The application of the network principle to 4-kv. service for such an area requires certain radical departures from the designs which have become fairly well established for distribution. Since underground construction in the areas of low-load density is not usually justifiable from an economic viewpoint, overhead construction must be used. The primary network deserves careful consideration from the standpoint of economy, reliability, and system planning in handling loads in areas not readily adaptable to low-voltage network distribution.

The past year has seen a continued application of vertical network distribution in large office buildings. This type of distribution has been used in a number of large cities including New York, Pittsburgh, and San Francisco. At the present time several features of design have not been settled. These features are being given consideration and it is expected that with the extended application of the vertical network principle a better understanding of them will result.

The question of secondary faults on low-voltage a-c. networks is still being discussed at length. There is a feeling among some engineers that the problem is not radically different from that encountered on the d-c. network. Others feel that short-circuit currents available are generally less and the condition is therefore more difficult. The use of buried cable has also been studied and tests made which will be reported in the near future.

SUBCOMMITTEE ON LIGHTNING AND INSULATORS

Past Year's Activities in Investigation Work

The activities in the field of lightning investigation during the past year have been carried on by means of:

1. Field investigation of natural lightning.
2. Field investigation with artificial lightning.
3. Collection of operating data on lightning performance of lines.
4. Theoretical analysis and coordination with the past lightning data.

In the field investigations, use was made of cathode-ray oscillographs, klydonographs (and surge recorders), surge indicators, lightning intensity recorders, direct-stroke recorders, and artificial lightning generators. This year the field investigation was extended to include a wood-pole line on which was recorded lightning voltages in the order of 5,000,000 volts.

By concentrated efforts in the field with the artificial lightning generator, a vast amount of knowledge has been gained on the effect of tower footing ground resistance, counterpoises, effect of normal voltage in sustaining a power arc in the presence of lightning flashover of a line, and particularly on the operation of the lightning arrester.

The behavior of traveling waves at the junction of cables with overhead lines was further studied by the use of the artificial lightning generator with particular attention to the application of lightning arresters.

Extensive use was made of the lightning (direct) stroke recorder and our knowledge in regard to the current in direct strokes amplified, and made more definite.

---

[*] COMMITTEE ON POWER TRANSMISSION AND DISTRIBUTION:

P. H. Chase, Chairman,
E. T. J. Brandon,
C. I. Burkholder,
A. B. Campbell,
C. V. Christie,
R. N. Conwell,
O. G. C. Dahl,
Harold C. Dean,
L. L. Elden,
H. S. Evans,
R. D. Evans,
F. M. Farmer,
J. H. Foote,
K. A. Hawley,
L. F. Hickernell,
J. P. Jollyman,
A. H. Lawton,
L. L. Perry,
T. F. Peterson,
D. W. Roper,
A. E. Silver,
D. M. Simmons,
C. T. Sinclair,
L. G. Smith,
Philip Sporn,
W. K. Vanderpoel,
C. F. Wagner,
H. S. Warren,
T. A. Worcester.

The cathode-ray oscillograph application was modified to trace the history of a natural lightning wave over a period of some 2,000 microseconds, in addition to recording the initial characteristics of the waves.

Surge indicators were used for the first time, although mentioned in last year's report. These definitely established the fact that a lightning flashover of a transmission line can take place without sufficient follow-up current flowing to trip out the line.

The past year has brought out some intensive study of a theoretical nature on the lightning problem dealing with the mechanism of the lightning stroke and the subsequent surges which may appear on a transmission line. Both the direct stroke and induced stroke have been analyzed and the conclusion pointed out that only direct strokes appear to have consequential effect on the highly insulated lines, while medium and lower insulated lines will be affected in an increasing order by induced strokes.

Results of Last Year's Work

It is impossible here to point out in detail all the results of last year's investigation. There are, however, some outstanding accomplishments, among which the following are cited.

1. The effectiveness of ground wires in reducing lightning voltages and line outages has been further demonstrated.
2. The value of low tower footing resistance in lessening the effects of lightning voltages has been shown.
3. Currents in the lightning stroke in the order of from 50,000 amperes and upwards have been indicated.
4. Counterpoises at a tower footing, even although of comparatively short length are beneficial in reducing the lightning voltage to which a line may be subjected.
5. Lightning sparkover of a line can take place without power follow current.
6. Lightning voltages of both direct and induced stroke origin appear to be present on transmission lines. It is not known in what normal insulation and voltage range the induced voltage ceases to be a factor in line flashover.

Insulation Coordination

In order to coordinate insulation on a lightning basis, its lightning characteristics must be known. Whether these are secured on a single impulse wave or voltage time lag basis, a standard test method must be agreed upon by all who supply this type of data. The Committee has this matter well in hand at the present time, with the probability that an agreement will soon be reached by all actively engaged in this work whereby a group of two or more preferred waves will be used for securing this type of data.

Insulator Flashover Values.

It has been known for some time past that discrepancies have existed in 60-cycle flashover values assigned to insulators of practically the same physical dimensions. The cause for these different flashover values has been traced to a variation in humidity conditions at the time and place of test. A great deal of experimental work has been done on this problem, and it is expected the information obtained will soon be made public through a group of papers before the Institute.

SUBCOMMITTEE ON INTERCONNECTION AND STABILITY FACTORS

In order to coordinate the work of the Power Generation Committee, the Protective Devices Committee and the Power Transmission and Distribution Committee in the field of interconnection and system stability, there has been formed a Joint Interconnection Subcommittee. This Subcommittee was organized during the year and has arranged several sessions of interest in the field of transmission and distribution. These include the session on System Grounding at the Pittsburgh Meeting in March 1931 and the session on System Interconnection for the Summer Convention of 1931. In addition, plans are under way for a symposium at the Winter Convention of 1932 on the subject of Machine Characteristics and System Stability. In last year's report mention was made of the organization of a Subject Committee on Definitions of Terms Used in Stability Investigations. The work of this Subject Committee is now substantially complete and it is planned to present it as a paper at the Winter Convention in 1932.

SUBCOMMITTEE ON CABLE DEVELOPMENTS

This year has witnessed the continued practically universal use of shielded cable (type H) for all three-conductor high-voltage cables. Other tendencies are the increased use of oil-filled cables, the use of super-calendered paper, a great increase in the use of non-metallic armored cables for direct burial in the ground for low-voltage work, and the use of steel-wire armored, non-leaded cables for submarine service and for vertical distribution cables in high buildings.

The Following Cable Installations May Be Noted:

1. A second circuit, 175,000 kva. (winter rating), of single-conductor 132-kv. oil-filled cable about 6 miles long by Commonwealth Edison Co. in the same conduit bank as their first circuit. The new circuit has 1,100,000 cir. mils conductors as compared with the 600,000 cir. mils previously used. The larger conductor size is made commercially feasible by insulating sleeves and grounding devices to eliminate sheath losses. Due to the many improvements in accessories and technique, the net result was that the investment cost per kva. of capacity is less than one-half the cost of the first line.

2. Two lines of single-conductor 600,000-cir. mil 132-kv. cables each three-quarters of a mile long installed by the Commonwealth Edison Co. one (90,000 kva. rating) similar to the cable of paragraph 1 above, and the other (95,000 kva. rating) with novel features of oil channels cut in the interior of the lead sheath as well as an oil channel in the conductor, a simple and small stop-joint, making it possible to have every joint a stop-joint, which joint is practically a factory-made and factory-tested joint.

3. The Deepwater installation of the United Gas Improvement Co. across the Delaware River consisting of two 60,000-kva. circuits (and two spare cables) of single-conductor 750,000-cir. mil 75-kv. solid type cable manufactured and installed in single lengths each about 4,000 ft. long. These are the first 75-kv. submarine cables and longest lengths of power cable ever manufactured.

4. Two circuits rated at 55,000 kva. each of single-conductor 750,000-cir. mil 75-kv. solid type submarine cable of the Union Electric Light and Power Co. of St. Louis across the Mississippi. The cables were made and installed in single lengths of about 2,800 ft. each.

5. An installation of five three-conductor 48,000-kva. 66-kv. oil-filled cables by the Union Gas and Electric Co. of Cincinnati. This is the first three-conductor 66-kv. oil-filled cable, and is buried direct in the ground. The conductor size is 500,000 cir. mils sector, insulated with 0.40 in. impregnated paper and shielded. The cables are made in single lengths 1,300 ft. long, thus avoiding joints, and are steel-tape armored cables buried directly in the ground.

6. Three commercial installations have been made during the year of three-conductor 33-kv. to 35-kv. oil-filled cable, although the amounts were rather limited. These installations were made by the city of Los Angeles, the Staten Island Edison Co., and the Syracuse Lighting Co. All three installations were made with three-conductor type H cable with oil channels in the filler spaces. A novel feature was the three-conductor positive stop-joint by the city of Los Angeles, and also the fact that a large installation of cable with oil channels in the filler spaces including a more viscous oil was installed by this company, who after installation replaced the oil in the channels by oil of the type used in oil-filled cables.

7. An experimental installation of single-conductor 132-kv. oil-filled cable by the Commonwealth Edison Co. of Chicago in cooperation with two manufacturers, each of whom supplied 1,000 ft. of 450,000-cir. mil or 500,000-cir. mil cable insulated with 0.40 in. paper and 1,000 ft. with 0.50 in. paper. The purpose of this experiment is to study the limiting stresses and temperatures in oil-filled cable for present and future voltages.

8. An experimental installation of single-conductor 132-kv. cable by the Public Service Electric and Gas Co. as a continuation of their 1927 experiment studying the possibility of "solid type" insulation for 132-kv. service. The installation consists of three cables each of 500,000 cir. mils and 1,000 ft. long, two supplied by one manufacturer and one by another. Each manufacturer supplied a length of solid-type cable. The third cable is of an intermediate or hybrid type, using oil intermediate in viscosity between that of an oil-filled cable and of the usual type of cable, thus greatly facilitating installation methods while sharing in part the operating advantages of an oil-filled cable.

The Subcommittee on Conduit and Manhole Temperature of the N. E. L. A. Underground Systems Committee has standardized on conditions and constants for calculating current-carrying capacity. This standardization has made it possible to calculate current-carrying capacities of cables covering a large range of sizes and conditions. These tables of carrying capacities will be published by the Underground Systems Committee, and should prove of great value to the industry.

SUBCOMMITTEE ON STEEL TRANSMISSION TOWERS AND CONDUCTORS

The Subcommittee on Steel Transmission Towers and Conductors was organized to assist in the standardization of steel transmission towers and conductors by clarifying the problems associated with their design and application, by papers prepared by recognized authorities on these subjects and presented before the Institute.

The work of the Subcommittee has been divided into three groups, each of which is responsible for one of the following subjects:

I—Towers.

II—Clearances and Electrical Characteristics.

III—Conductors.

During the past year, four meetings of the Subcommittee have been held, together with some additional meetings of groups within the Subcommittee.

An addition to the clause of the N. E. L. A. specifications on uplift of tower foundations and a recommendation for a straight line compression formula for the N. E. L. A. specifications is in course of preparation. Consideration is being given to elimination of the term "factor of safety" by substituting therefore "per cent overload." Contact is being maintained with the A. S. T. M. on its investigation of embrittlement of hot dipped, galvanized steel.

It is proposed to recommend that the 60-cycle flashover be the basis for clearance of the tower under winter or heavy loading conditions and that lightning flashover be the limit for summer or light loading conditions. The width of the right-of-way is to be limited by similar conditions.

Intensive study is being given to the vibration of conductors. Efforts are being directed principally to the coordination of experimental work being done by widely separated investigators, including California, Texas, Illinois, Michigan, Ontario, England, and Australia. A bibliography is being established as an adjunct to this work.

The present membership of this committee, including the chairman, is now twenty, with five men in Group I, six men in Group II and eight men in Group III.

It is felt that the work of this subcommittee is now progressing smoothly and during the next year, concrete results can be shown as the result of its activities.

CONCLUSION

For the sake of brevity, this year's report excludes the bibliographies of papers which appeared in last year's report. It is planned to include such bibliographies in the Annual Report at appropriate intervals, rather than every year.

In conclusion, it is desired to stress the conscientious and enthusiastic work of the chairmen and members of the subcommittees to whose liberal contributions of time the progress made is due.

Transportation

ANNUAL REPORT OF THE COMMITTEE ON TRANSPORTATION*

YOUR Committee on Transportation submits a brief review of the recent developments of importance in the application of electricity to transportation.

STEAM RAILROAD ELECTRIFICATION

Pennsylvania Railroad

The Pennsylvania Railroad has been actively continuing its electrification program. On June 29, 1930 electric operation was inaugurated between Philadelphia and Trenton, N. J., a distance of about thirty miles. On July 20th, electric operation was started between Philadelphia and Norristown, Pa., on the Schuylkill Division, seventeen miles. Fifty-nine multiple unit cars have been recently acquired. This installation completes the suburban electrification about Philadelphia. Distribution of power is at 11,000 volts, 25-cycle, single-phase. The equipment for suburban service is at present all motor cars, with multiple unit control.

The new suburban terminal at Broad Street was opened on September 28th. This is of necessity, entirely electrically operated, for the tracks are, like those of the passenger terminal at New York, under cover. The new suburban station at Thirtieth Street on the west bank of the Schuylkill River was also placed in service at this time. This will ultimately be an integral part of the Pennsylvania Terminal at West Philadelphia now under construction.

The Pennsylvania Railroad now has in electrified operation about Philadelphia, 132 miles of route and 437 miles of track; 345 multiple unit cars are in service.

Work is actively progressing in the New York Terminal zone preparatory to changing from the 600-volt third rail to 11,000-volt, single-phase trolley wire between Sunnyside Yard and Manhattan Transfer. This installation, which will among other things allow New Haven locomotives to enter the Manhattan Terminal, should be completed during the present year.

Construction is progressing between New Brunswick and Manhattan Transfer and will shortly be started between New Brunswick and Trenton, and between Wilmington and Washington.

Four types of locomotives are being developed for the complete electrification. Two passenger types, one freight and one yard switching. The light passenger type (designated as 0-1) is of 2-B-2 arrangement, and two of these units will be used on the heavy passenger trains. The heavy passenger type (P-5) is of the 2-C-2 arrangement. The freight type (L-6) is of the 1-D-1 arrangement. The passenger locomotives will use twin motors rated at 500 hp. per armature, or 1,000 hp. per axle. The freight locomotive will be equipped with four motors of single armature type, and will thus have a rated capacity of about 2,000 hp.

Long Island Railroad

The multiple unit suburban service of the Long Island portion of the Pennsylvania Railroad, operated by third rail distribution, is rapidly growing. Eighty-five multiple unit cars now being added to the equipment, bring the total number of cars to 825. To provide power for the increasing load, the Floral Park substation is being remodeled and will be equipped with two rectifiers of 3,000-kw. capacity. Four new substations—Hempstead, Manhasset, Rockaway Park, and Goose Creek—are being built, in addition to four planned for installation next year. Each of the new substations will contain one 3,000-kw. mercury arc rectifier, except at Goose Creek where portable synchronous converter equipment will be installed. The rectifiers will be adapted for 60 or 25 cycle operation, an external reactance being added for the lower frequency.

---

*COMMITTEE ON TRANSPORTATION:

Sidney Withington, Chairman,

P. P. Ash,
R. Beeuwkes,
A. E. Bettis,
J. V. B. Duer,
H. H. Field,
L. W. Fisk,
W. A. Giger,

K. T. Healy,
D. C. Jackson,
J. Murphy,
I. Ofverholm,
H. Parodi,
W. B. Potter,
R. H. Price,

A. S. Richey,
S. A. Spalding,
N. W. Storer,
W. M. Vandersluis,
R. H. Wheeler,
R. P. Winton,
G. I. Wright.

Delaware, Lackawanna & Western Railroad

The suburban electrification of the D. L. & W. R. R. was inaugurated between Hoboken and Montclair, N. J. on September 3, 1930, the service to South Orange, N. J. September 22, 1930 and that to Morristown, N. J. December 18th. The present electric installation was completed with the electric operation in January 1931 to Gladstone and Dover, N. J. This electric operation comprises about sixty-eight route miles and one hundred and fifty-eight miles of track; and includes 282 multiple unit cars. These cars operate in pairs, the units consisting of one motor car and one trailer each. Five substations, each containing mercury arc rectifiers, furnish the distribution power at 3,000 volts direct current. Two electric three-power locomotives (oil, storage battery, and trolley operated) have been acquired and are used for switching and transfer service between Jersey City and Secaucus freight yards. The D. L. & W. is the first heavy traction service in this country to utilize 3,000-volt direct current on motor cars, and the first to install exclusively mercury arc rectifiers.

New York Central Railroad

The Cleveland Union Terminal electric operation was inaugurated June 28, 1930. This project comprises 17 miles of route and about 60 miles of track, between Collinwood and Linndale, Ohio, and employs twenty-two locomotives. These locomotives are 2-C + C-2, weighing about 204 tons, of which 150 tons is on drivers. They are designed for a maximum speed of 70 mi. per hr. The locomotives are used interchangeably for switching or road service. Train heating boilers, oil-fired, are provided on the locomotives. The power distribution is by means of 3,000-volt direct current, using a catenary system. This is supplied from two substations, one 3.5 miles west, and the other 7.2 miles east, of the Union Station; each equipped with motor-generators, remotely controlled from the terminal building by a supervisory system of the synchronous selective type. The installed capacity is 9,000 kw and 6,000 kw. respectively.

The New York City electrification of the New York Central is progressing. The "West Side" tracks will be electrified by the middle of the current year as far south as Seventy-second Street, the tracks north of that point being on a viaduct, or on private right-of-way. Forty-two freight locomotives have been purchased for this service. Distribution of power is by direct current at 650 volts using a third rail. South of Seventy-second Street the tracks are on city streets, and the operation will be accomplished by three-power (oil-electric-storage battery) locomotives, of which the railroad has purchased thirty-five.

Reading Railroad

The electrification of the Reading Railroad at Philadelphia is progressing, and operation should be started about the middle of the current year. This project includes about 69 route miles and 161 miles of track; seventy multiple unit cars will be operated initially. The distribution system is at 11,000 volts, single-phase, 25 cycles.

Great Northern Railway

The Great Northern Railway has placed in service four new motor-generator locomotives with axle arrangement 1-C + C-1, essentially similar to those of that type already in operation. Each locomotive weighs 263 tons, of which 210 tons is on drivers. The distribution of power is at 11,000 volts, 25 cycles, single-phase.

Illinois Central

The Illinois Central Railroad placed in service in 1930, four 100-ton straight-electric locomotives for switching service, and also five 600-hp. oil-electric locomotives of the Diesel type. The motive power now in suburban service consists of 280 multiple unit cars, 140 of which are motor cars and 140 are trailers. In the freight switching service, there are now four straight-electric locomotives and six 600-hp. oil-electric. The power distribution is 1,500 volts, direct current. About 154 track miles are electrified.

New York, New Haven and Hartford Railroad

The final extension of the New York, Westchester and Boston Railway to Port Chester, N. Y. was completed late in 1929. The New York, Westchester and Boston—an integral part of the New Haven electric operation, now operates from Harlem River to Mount Vernon, N. Y., with branches to White Plains, N. Y. and to Port Chester, N. Y. The total New Haven a-c. electrified mileage is now about 577 track miles, over approximately 116 miles of route. The road operated, as of the end of 1930, 141 electric locomotives and 267 multiple-unit cars. The New Haven last year placed in service nine multiple-unit cars. During the current year there will be added to the equipment, ten 200-ton passenger locomotives and 33 multiple-unit cars. The power distribution of the New Haven is at 11,000 volts single-phase, 25 cycles, but the passenger motive power is designed to take power also from the New York Central third rail at 650 volts, direct current.

Substations for Electrified Railroads

The conversion of power for distribution on the Delaware, Lackawanna and Western electrification is, as previously noted, entirely by means of mercury arc rectifiers. This installation consists of 18 units in 5 substations with a total capacity of 40,000 kw. The rectifiers are also provided with a means of compounding, so that voltage can be maintained over a fairly wide load range at substations. Reference is made to the report of the Technical Committee on Automatic Stations covering this feature. Four of the substations are manually operated but are provided with many of the usual automatic protective features. One substation is completely automatic. Remote and supervisory control are provided for the automatic substation and the tie stations.

In its electrification the Pennsylvania Railroad has continued with the 11,000-volt distribution system now in use on other parts of its system involving step-down transformer substations installed at intervals of 7 to 8 miles. The Reading electrification consists of the three-wire distribution system with 11,000 volts on the trolley and a feeder of 33,000 volts. Auto transformer stations are used at intervals, to transfer energy from the 33,000-volt feeder to the 11,000-volt trolley. Some of the substations of the Pennsylvania Railroad electrification are remotely controlled from adjacent signal towers, and those of the Reading are controlled by supervisory control so that the power director indirectly or directly has control of all circuit breakers within his jurisdiction.

The Cleveland Union Terminal Substations contain two and three 3,000-kw. motor-generator sets respectively, with complete automatic control. A synchronous selective supervisory control system with remote telemetering provides the dispatcher, located in the Terminal Building, with complete supervision and indication of the substation, feeders and tie station.

High-speed air circuit breakers have been employed in all substations of the d-c. systems mentioned above, and the Pennsylvania Railroad and Reading Railroad a-c. systems have employed high-speed a-c. breakers of the air and oil type. Reference is made to the report of the Committee on Protective Devices for data regarding the various types of high-speed circuit breakers available for a-c. and d-c. service.

Electric Locomotives

A novel development in the field of a-c. locomotive design has occurred abroad. In this design the low-voltage terminals of the transformer are permanently brought out, and all voltage control for the motors is by means of an oil-immersed tap changer and air switches from the high-voltage windings. The arrangement is a development of the growing use of the scheme of "tap-changing under load" and if it is found to be practicable under service conditions, should materially simplify the design of a-c locomotives.

A novel development in electric locomotive design has been accomplished in the new locomotive of the Illinois Central Railroad. This compensates the tendency of reduced weight upon the forward drivers at high drawbar loads, especially at starting, on account of the moment of the drawbar pull and rail reaction. The arrangement consists of shunts for weakening the field of the leading motor of each truck, which reduces the tractive effort of the leading motor and increases that of the rear, in proportion to the field strengths of the two motors. The forward drivers thus show less tendency to slip and the drawbar capacity is therefore increased.

There has been a number of notable improvements recently in the design and construction of the single-phase motor which have materially decreased its weight per horsepower and have improved efficiency and power factor. Attention is called to the report of the Committee on Electrical Machinery for descriptions of these developments.

Oil-Electric Locomotives

In addition to 35 oil-electric-storage battery locomotives acquired by the New York Central Railroad for the "West Side" operation in New York City, seven similar units have been placed in service in Chicago, and as above stated, two on the Delaware, Lackawanna & Western Railroad. The Canadian National last year acquired a Diesel locomotive, as have various industrial concerns.

A novel arrangement of Diesel locomotives has been developed, wherein the engineer's driving position is raised to a sort of mezzanine floor, so the engineer may look over the top of the train he is moving. In this design, controllers, air brake handles, etc., are provided at both sides of the cab so the driver may move from side to side as desired to observe signals from the switching crew.

Rail Cars

Fifty-six rail cars of gasoline and oil electric design were produced in this country during the past year. As an indication of the increasing use of this type of equipment in heavier service, the average power of these cars was about 450 hp. as compared with about 350 hp. the average in 1928.

MARINE TRANSPORTATION

A number of turbo-electric and Diesel-electric vessels of various types was produced in 1930. The *S.S. President Hoover* is the largest electrically driven liner produced thus far. The propelling equipment consists of two 14,000 hp. turbines with three-phase 10,100-kw. generators, and two 13,250-hp. synchronous induction motors. Auxiliary electric apparatus on steam and Diesel propelled craft has developed in a number of different directions, replacing steam auxiliaries. Attention is called to the report of the Technical Committee on Application of Electricity to Marine work.

AVIATION

A number of electrical devices has added to the art of aviation during the past year. Among these is the "turn compensator," an electrically driven device to correct the error experienced in all types of "earth inductor" compasses when the direction of the ship is suddenly changed. This device may also be used as a "turn indicator" to show quickly and with reasonable accuracy the angular change in direction.

Recently developed engine-performance indicators, electrically operated, showing oil-pressure, oil-temperature, speed, etc., are of value especially on multiple-engine ships, by permitting remote indication.

In the field of illumination for aviation, wing-lights set into the leading edge of plane wings increase efficiency by reducing non-productive air resistance. Airways are being illuminated by increasingly powerful and efficient beacons. The illumination of landing fields by means of flood lights and marking lights is keeping pace with other developments.

RAILROAD SIGNALING

Centralized traffic control by means of coding systems is rapidly being extended on railroads. This enables a dispatcher or tower operator to remotely control switches and signals over a large territory and thus direct trains quickly and effectively without the necessity of train orders.

URBAN TRANSPORTATION

The chief developments in urban transportation are efforts to obtain faster car acceleration, higher speeds, and better braking, to compete with increasingly difficult traffic conditions. The increased use of double-reduction and worm gears has made the operation of higher speed motors practicable with marked decrease in weight (especially in unsprung weight). Lower floors, with greater speed in loading and unloading, are features of some of the new drives.

The modern trolley bus is being used for many services where street cars or gasoline buses were applied previously. Economy of operation and low investment cost insure a widespread use of trolley buses, especially where it is possible to utilize existing power plant, substation, and power distribution facilities. In Chicago, for instance, over fifty-seven miles of line have been equipped for trolley bus operation, and seventy-five buses are in use.

The gas-electric coach, which has hitherto shown its chief advantages in congested urban traffic where frequent and rapid acceleration is necessary, is invading the interurban field.

Attention is called to the expansion of the subway mileage in Philadelphia, New York, and Brooklyn. Plans for a subway in Chicago have been approved.

RAIL FISSURE DETECTOR

The Sperry device for detecting fissures in track rails has been operated intensively throughout the country with valuable results. Continued use of this device should materially reduce rail failures.

WELDING

Electric welding is increasingly used not only in railroad shops (as in other industries), but for building up rails and "special work" at frogs, crossings, etc. Rail bonds for traction and signal purposes are in many instances welded to the head of the rails.

VERTICAL TRANSPORTATION

The ever increasing height of buildings necessitates constantly increasing efficiency and speed of elevators. Speeds of 900 ft. per min. are now operated. A recent development to increase space efficiency in high buildings, is the operation of two or more elevators in a single shaft, so synchronized that one elevator may be started and run as "express" for a certain number of floors before the car next below it starts. Needless to say the operation is interlocked by means of limit switches and kindred devices to prevent the cars from coming together.

GENERAL

Attention is called to the development of various types of apparatus which apply to transportation as well as to other forms of utilization of electricity as described in various technical committee reports. Included in this category are turbo-generators and other power plant facilities, motors, circuit breakers, insulators, transformers, lightning arresters, cables, relays, substations, etc. Many of these types of apparatus are applicable to transportation, only by accomplishing some more or less important modifications, and the attention of various technical committees has been called to special modifications of this kind.

Attention is called to the work which is being carried on under the auspices of the American Standards Association on Definitions of Electrical Terms (C-42) for which the A. I. E. E. is sponsor. To Subcommittee No. 6 is assigned the field of "Horizontal Transportation." It is hoped that when this very important subject is complete, and published, general use will be made of the definitions and that some confusion which now exists will thus be avoided.

Protective Devices

ANNUAL REPORT OF COMMITTEE ON PROTECTIVE DEVICES*

THE work of the Committee on Protective Devices during the past year was accomplished largely through subcommittees, which are listed below with their chairmen:

Relays, W. W. Edson; Oil Circuit Breakers, Switches and Fuses, L. F. Hickernell; Lightning Arresters, H. K. Sels; Fault Current Limiting Devices, H. B. Wood; Joint Interconnection Subcommittee,† F. C. Hanker.

The activities of the Protective Devices Committee may be divided into the following three classes:

1. Preparation of standards
2. Review of research and development
3. Fostering the preparation and presentation of papers.

GENERAL

During the year the work of the committee in cooperation with the National Electric Light Association in the preparation of a supplement to the Relay Handbook was completed.

Revised standards for lightning arresters have been prepared and issued in report form by the Standards Committee.

Progress has been made in the preparation of standards for fuses and revised standards for disconnecting, horn gap and knife switches. It was hoped that the standard for fuses could be sent to the Standards Committee this year, but due to difficulties in obtaining complete agreement as to the subject matter of this standard there has been some delay. These standards should be forwarded to the Standards Committee in the latter part of 1931.

The committee has maintained close contact with research and development relating particularly to lightning protection, high-speed oil circuit breakers, and stability of operation, which greatly facilitated its work in fostering the preparation of suitable papers relating to these subjects.

The work of the committee during the past year has emphasized more than ever the following points. First, the desirability of planning the presentation of papers sufficiently in advance so that they may be grouped for presentation in the most suitable manner. Second, the necessity, if maximum advantage is to be realized from Institute sessions, of having papers available for reading sufficient time in advance of meetings to permit of well considered discussion. The importance of this latter point is so great that every effort should be made to see that it is carried out effectively.

On account of the fact that in a number of cases other technical committees of the Institute have a very definite interest in the application or use of devices coming under the jurisdiction of the Protective Devices Committee, very close coordination of activities is required. This is particularly true in matters relating to interconnection and stability of operation handled at the present time by the joint subcommittee having representatives from the Power Generation and Power Transmission and Distribution Committees, in addition to the Protective Devices Committee. It may be that there will be sufficient important matters which affect a number of committees to warrant selecting some method of handling them that will permit of direct effective action without the complication and delays that are bound to happen in coordinating work with several large committees.

RELAYS

Report of Subcommittee

Further development of high-voltage transmission and interconnection with rather severe requirements as to stability and continuity of service, have focused attention on the necessity of rapid clearing with extreme precision, and the development of the art of relay protection has advanced as a consequence. Relays have been developed including directional, balanced, and differential relays capable of operating in one-sixtieth of a second.

These are being tried out in service and their operation is being watched with much interest. Apparently, additional work should be done to simplify these relays and their mechanical construction details, so as to insure among other things high-speed operation under all conditions, and to prevent shifting of the balance point. Also, further development will apparently have to be gone ahead with to eliminate certain difficulties in the application of these relays to short line sections or to ground protection.

---

*COMMITTEE ON PROTECTIVE DEVICES:

Raymond Bailey, Chairman,
J. E. Allen,
A. C. Cummins,
H. W. Drake,
W. S. Edsall,
W. W. Edson,
L. E. Frost,
E. B. George,
Herman Halperin,
F. C. Hanker,
E. A. Hester,
L. F. Hickernell,
Dr. M. G. Lloyd,
J. P. McKearin,
H. A. McLaughlin,
A. M. Rossman,
A. H. Schirmer,
H. K. Sels,
H. P. Sleeper,
E. R. Stauffacher,
H. R. Summerhayes,
E. M. Wood,
H. B. Wood.

†This is a joint subcommittee of the committee on Power Generation, Power Transmission and Distribution and the Protective Devices Committee.

The most important work of the subcommittee for the year is the completion of the revised edition of the Relay Handbook, in cooperation with the corresponding committee of the N. E. L. A.

The following papers, prepared under the auspices of this subcommittee, have been presented before the Institute:

Relay Developments on Southern California Edison System, E. R. Stauffacher, Southern California Edison Company.

Operating Experience with Reactance Type Distance Relays, E. E. George, the Tennessee Electric Power Company.

Protection of Three-Winding Power Transformers, R. E. Cordray, General Electric Company.

Fundamental Basis of Distance Relaying, W. A. Lewis, Westinghouse Elec. & Mfg. Company.

OIL CIRCUIT BREAKERS, SWITCHES, AND FUSES

Report of Subcommittee

A prominent feature of oil circuit breaker development is the number of large installations of metal-clad switchgear. Among these may be mentioned the installation of 33-kv. oil-filled gear on the system of the Public Service Company of Northern Illinois, the 13-kv. gum-filled gear at the Leaside Substation of the Hydro-Electric Power Commission, and air-filled gear on the system of the Jersey Central Power & Light Company.

Since last year's development of the deion circuit breaker, further results have followed the discovery of this method of arc extinction. With the addition of deion grids, ordinary oil circuit breakers have opened 3,500 amperes at 110,000 volts with 1.5 cycles of arcing; and 3,000 amperes at 200,000 volts with 3.5 cycles of arcing or less. Decreased arcing assures more satisfactory breaker performance, less deterioration of oil and contacts and lower maintenance. The stability of the whole power system is improved, since short circuits are more likely to be cleared before they can affect synchronous machines.

The deion oil-less breaker in the meanwhile has been developed for a greater range of ratings. At one extreme is a one million kva. 23 kv. circuit breaker which has undergone interrupting capacity tests including some shots as high as 800,000 kva. (It will be recalled that among last year's achievements were reported successful interruptions of short circuits in the order of 60,000 kva.) On the other extreme is the breaker (using 2.5-inch plates) which repeatedly interrupted 10,000 amperes at 600 volts alternating current. This small deion breaker shows great promise in a wide field of the moderate and smaller powers; such, perhaps, as industrial service.

Efforts to improve rating standards for oil circuit breakers continue.

Announcements by the manufacturers indicate healthy activity in the development of new forms of circuit interrupters, such as the oil-blast oil-circuit breakers, multiple break and others.

The following papers, prepared under the auspices of this subcommittee, have been presented before the Institute:

The Mechanical Performance of Oil Circuit Breakers, A. C. Schwager, Pacific Electric Mfg. Co.

Outdoor Switching Equipment at Northwest Station, W. F. Sims and C. G. Axell, Commonwealth Edison Co.

Magnitudes and Rates of Rise of Circuit Breaker Recovery Voltages, R. H. Park and W. F. Skeats, General Electric Co.

Trend in Development of Modern Circuit Interrupters, J. B. MacNeill, Westinghouse Elec. & Mfg. Co.

Oil Circuit Breaker Tests—Philo 1930; Aims, Set-Up and Results from a System and Operating Point of View, Philip Sporn and H. P. St. Clair, American Gas & Elec. Co.

The Oil-Blast Circuit Breaker, D. C. Prince and W. F. Skeats, General Electric Co.

Field Tests on Standard and Oil-Blast Explosion Chamber Oil Circuit Breakers, R. M. Spurck and H. E. Strang, General Electric Company.

LIGHTNING ARRESTERS

Report of Subcommittee

The Subcommittee is advised that studies of lightning and the effects of lightning were continued throughout the year by means of field investigations on transmission systems in several widely separated localities. The knowledge of the character and behavior of high-voltage surges originating from lightning on transmission lines was extended by the use of cathode-ray oscillographs at field stations located in Arkansas, Illinois, Michigan, New Jersey, Ohio, Pennsylvania, and West Virginia. In two cases, Michigan and New Jersey, the behavior of waves on transmission lines was studied in detail by the use of both portable cathode-ray oscillographs and impulse generators. Practically a continuous investigation was maintained also of the performance of lightning arresters and many other associated phases of the lightning protection problem. About 3,000 oscillograms were taken which have already proved valuable in the study of problems related to lightning protection.

Better coordination of records in the 1930 lightning investigations has indicated the growing importance of direct strokes. Records obtained on high-voltage lines tend to confirm the thought that overvoltage due to direct strokes are more important than those due to the induced effect from lightning strokes primarily on account of their greater magnitude.

Impulse tests made in the field tend to confirm the conclusion that best protection with lightning arresters is obtained when the arrester is located close to the equipment to be protected and the leads as short as possible with low ground resistance. If the arrester cannot be located close to the equipment and at the same time retain short leads, keeping the leads short appears to be the more important. Also, the arrester and equipment should be connected to the same ground but if this is not convenient, more attention must be given to the arrester ground to be sure that its resistance is as low as possible.

The highest voltage lightning arresters ever built were recently installed by the Hydro-Electric Power Commission of Ontario. Under emergency conditions of generator overspeed and abnormal line voltage, they will not be damaged by voltages as high as 268,400 volts. Normally, four of the twenty-two arrester units in each phase leg are short circuited by a high speed switch which opens automatically in less than half a second when waterwheel overspeed and overvoltage occurs. This is also the largest arrester installation for voltages over 200,000. One three-phase arrester is installed for the protection of each of four banks of transformers.

The commercial development of the porous block autovalve arrester has made available a new arrester which is considerably smaller and has much better performance characteristics than the earlier autovalve. The arrester is constructed in fewer porcelain-cased units with a totally enclosed gap structure which in the lower voltage sizes results in the complete arrester being housed in a single casing or two casings with gaps and elements separate. The protective action of the arrester is similar to the old one but it has practically no time lag in its operation and a low ratio of discharge voltage to normal voltage. A small and compact form of line arrester has been developed which can be applied to prevent the flashover of insulator strings. A number of installations of these line arresters has been under observation for the past two years in order to gather data on the effectiveness of such protection for transmission line insulators.

With the commercial development of thyrite, a new form of lightning arrester became available. The arrester is constructed in the form of self-contained units, it only being necessary for any application to mount an appropriate number of units one upon another. A gap structure has been provided in each unit so constructed that substantially no time lag occurs in the operation of the gap. This arrangement, coupled with the characteristics of the material, insures an arrester which has practically no time lag in its operation. A number of installations of these arresters has been made, the highest voltage arrester in service being of 230 kv. rating. Another form of thyrite arrester was developed which is incorporated in a string of suspension insulators and used to prevent the flashover of the insulator string for all but the most severe conditions.

A new protective device operating on a deion principle in a small bore tube for use in the prevention of insulator flashover by lightning has been developed in certain voltage ratings.

The revision of the proposed Standards for Lightning Arresters for alternating-current power circuits was completed and accepted by the Committee on Protective Devices for printing in report form. The subcommittee hopes that there will be widespread use of these standards in order that they may be put in final shape for adoption by the Institute. It is expected that development in the art of protection from lightning will probably make it necessary to revise these standards from time to time as additional technical information becomes available.

The work of the subcommittee indicates that the following matters should receive considerable attention in the future: (1) the determination of more representative test surges, (2) the development of tests to determine operating condition of arresters in service, (3) investigation of present operating practise on transmission and distribution systems relative to arrester installation, operation and performance as affecting suitable standards, and (4) the coordination of line and station type arrester application in the field with the activities of other committees interested in the grading of system insulation.

The following papers, prepared under the auspices of this subcommittee, have been presented before the Institute:

An Experimental Lightning Protector for Insulators, J. J. Torok, Westinghouse Elec. & Mfg. Co.

Field Tests on Thyrite Lightning Arresters Using Artificial Lightning of 1,500,000 Volts, K. B. McEachron and E. J. Wade, General Electric Company.

FAULT CURRENT LIMITING DEVICES

Report of Subcommittee

The reactor installations made during the year are characterized by high electrical ratings and greater physical size, particularly in bus-sectionalizing applications which seem to be on the increase.

Among the largest ever built in physical size is an application of 4,000-kva., 161-kv. bus sectionalizing reactors giving 10 per cent reactive drop when 120,000 kva. is transferred across the reactor.

Another outstanding installation from the standpoint of physical size consists of three 5,400-kva. oil-immersed reactors on the 110-kv. system of the Pacific Gas & Electric Co.

Noteworthy from the standpoint of electrical rating are eighteen bus-sectionalizing reactors rated 7,340 kva. giving a 16½ per cent reactive drop in a 133,000-kva., 27,600-volt circuit now on order.

Current-limiting reactors of the dry type installed in metal housings and rated 833 kva., 693 volts, 1,200 amperes, 60 cycles, were used to sectionalize a 24,000-volt bus. They introduce 5 per cent reactive drop between the sections when 50,000 kva. are being transferred. The housings are supported on insulators and are connected to a ground bus.

Bus-sectionalizing reactors were in some instances provided with disconnecting devices which automatically break the circuit when the reactor is removed from its operating location.

Representative opinion has been secured on the desirability of including in the new A. I. E. E. Standard for Fault Current Limiting Devices the material on reactors now in A. I. E. E. Standards No. 13 and also information on grounding transformers, generator neutral reactors, and Petersen coils. As yet no definite decision has been reached.

INTERCONNECTIONS

Report of Joint Subcommittee

The work of the Joint Interconnections Subcommittee has related almost entirely to the preparation of papers. A comprehensive paper on *Present Day Practise in Grounding of System Neutrals* was prepared by the subcommittee and presented at the Pittsburgh District Meeting.

A paper entitled *Impulse Test on Substations*, by Messrs. Brookes, Southgate, Roman, and Whitehead, was presented at the Winter Convention.

The following papers were presented at the Pittsburgh Meeting:

Committee Report on Present Day Grounding Practises, C. A. Powel, Chairman.

Reactance of Transmission Lines with Ground Return, J. E. Clem, General Electric Company.

Power System Voltages and Currents Under Fault Conditions, R. D. Evans and S. H. Wright, Westinghouse Elec. & Mfg. Company.

Simultaneous Faults and Six-Phase Transmission, Edith Clarke, General Electric Company.

Power System Voltages and Currents Under Fault Conditions, R. D. Evans and S. H. Wright, Westinghouse Elec. & Mfg. Co.

Series Resistance Method of Increasing Transient Stability Limit, R. C. Bergvall, Westinghouse Elec. & Mfg. Co.

Research

ANNUAL REPORT OF COMMITTEE ON RESEARCH*

DURING the year the Committee members have reviewed twenty-six papers and recommendations have been made to Headquarters for their disposition. Each paper has been reviewed by three or more members and outside experts. The Committee held one session at the Winter Convention at which eight of the approved papers were presented. Additional papers, obtained through the Committee on Research, are scheduled for the Summer Convention and several papers made available for district meetings. All business was carried on through correspondence as the only Committee meeting scheduled, at the Winter Convention, had to be abandoned because of conflicts.

The following topics are of sufficient importance to be called to the attention of the electrical engineering profession. The subjects reported have all been suggested by the Committee members, special assistance having been given by Messrs. W. G. Cady, V. Karapetoff, H. H. Race, D. W. Roper, T. Spooner, and J. B. Whitehead.

PHYSICS

In the field of physics there has been a number of theoretical and experimental accomplishments of some interest during the past year.

The knowledge of cosmic rays has been advanced somewhat with two schools of thought: certain investigators, as a result of certain experimental evidence, are convinced that cosmic rays are actually high velocity particles. However, Dr. Millikan, from intensity measurement of the cosmic rays in northern latitudes, feels quite certain that they are actually rays, since they are not affected by the earth's magnetic field. Dr. Millikan concludes that the cosmic rays have their origin not in the stars, but in interstellar space and that they are due to the building up of the commoner heavy elements from hydrogen, it being thoroughly established by spectroscopy that hydrogen is widely distributed through space. Several of the more common elements and also helium exists in interstellar space.

After seven years of intensive work, Dr. Paul Heyl of the Bureau of Standards has remeasured the constant of gravitation, or as the newspapers would put it, the weight of the earth. This figure is 6.670×10^{-8} c. g. s. units.

Eddington has developed a theory which makes possible the calculation of the ratio of masses of an electron and proton as well as the sizes of the electron and of the universe.

The generation of very short radio waves is possible by a number of means, among them the Barkhausen tube. This tube is a three electrode tube with suitable voltages applied to the grid and plate and provided with parallel Lecher wires. The frequency is dependent on the speed of the electrons as affected by the voltages and spacing of the electrodes and is independent of the external characteristics. Shuster has applied quantum mechanics to the problem of the Barkhausen tube and has calculated correctly the observed frequencies.

---

*COMMITTEE ON RESEARCH:

L. W. Chubb, Chairman,
H. D. Arnold,
E. Bennett,
W. G. Cady,
E. H. Colpitts,
E. C. Crittenden,
W. F. Davidson,
W. P. Dobson,
F. M. Farmer,
J. Allen Johnson,
V. Karapetoff,
A. E. Kennelly,
J. K. McNeely,
F. W. Peek, Jr.,
H. H. Race,
C. W. Rice,
D. W. Roper,
T. Spooner,
J. B. Whitehead.

As a result of the work of Grondahl it has been known for some years that copper oxide on copper had a photoelectric effect, making possible the generation of electric energy from sunlight. Dr. B. Lange of the Kaiser Wilhelm Institute for silicate investigation has obtained some interesting results with the copper oxide cell. According to newspaper reports he has, with the use of silver selenide, obtained similar results, but of one hundred or more times as much magnitude. However, for the generation of power from sunlight, the development is very far from being commercial owing to the high cost and low output.

Medicine and Physiology

In the realm of medicine and physiology there has been a number of developments of interest to the electrical engineer. The recent paper on "Experiments on High Voltage Tubes," by Tuve, Hafstad, and Dahl of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, describes an X-ray tube, the voltage of which can be as high as 2,000 kilovolts. At 1,300 kilovolts the absorption coefficient, after filtering through one inch of lead is the same as that for the gamma rays from radium in equilibrium measured under the same conditions with the same instrument. This result has been attained by the so-called heat working of the pyrex glass. This high voltage tube should serve as a new tool to the medical profession.

For the treatment of cancer there has been developed by Dr. W. D. Coolidge a 900,000-volt X-ray tube to be installed in the New York Memorial Hospital.

It is well known that fever assists in destroying certain disease germs. It is possible, by the use of high frequency electrostatic fields, to produce artificial fever, thus assisting nature. Considerable success has been obtained by this method during the past year.

Dr. George Sperti of the University of Cincinnati has succeeded in using selected regions in the ultraviolet spectrum for the irradiation of foods; for example, he has been able to create Vitamin D in milk without spoiling the taste.

Dr. H. C. Rentschler has developed a method for measuring ultraviolet radiation by the use of a suitably designed photocell and a condenser. The condenser is charged slowly through the photocell and discharges through a counter at a rate dependent upon the ultraviolet radiation received by the photocell.

Dielectrics

Considerable progress has been made in insulation and dielectric research during the past year. Much work is being done to improve the processing in the manufacture of high-voltage cable insulation and also to detect a faulty impregnated cable before it goes into service. At Johns Hopkins University the value of thorough drying by the use of vacuum and air pressure during impregnation and the use of gas free oils have been studied further. To detect poor insulation, research workers of the University of Illinois are measuring high frequency discharges which constitute internal ionization.

Studies on the oils themselves are under way at the Detroit Edison Company, Cornell University, and the Brooklyn Edison Company, with special emphasis on the life characteristics and products of such oils under electrical stress, particularly ionic and electronic bombardment. At the Detroit Edison Company, it has been found that by bombardment of the oil vapors in a vacuum, the composition of the gas produced varies from one hydrocarbon to another and is quite complex, but consists roughly of 50 per cent hydrogen and 50 per cent unsaturated hydrocarbons. Liquids and wax-like solids are also produced. The solid formed is a duplicate of the compound "X" found in cables which have been in service. The formation of this substance in cables indicates internal corona. Five normal paraffin hydrocarbons of simple chemical structure and of very high purity have been prepared at the Bureau of Standards and studies are being made of their electrical characteristics.

Further studies have been made of polar compounds in liquid dielectrics. The frequency-temperature-loss characteristics have been studied in a number of laboratories with most interesting results. In addition, the polar characteristics of certain commercial insulating liquids are being studied, particularly the change and polar characteristics during service. These fundamental studies should aid in a choice of better insulating oils.

At Johns Hopkins University correlation between d-c. absorption and a-c. dielectric loss has been verified for several oils, dried paper and impregnated paper consisting of the materials previously studied alone. The relatively high d-c. conductivity of oil obtained up to about one second after electrification was found to account for the a-c. losses. The electrical characteristics of the separate and combined materials of impregnated paper insulation have been studied. This is a very important step in the fundamental side of dielectric research.

Another field of investigation which is just getting under way is the use of X-rays to study the molecular structure of dielectrics. The work of Dr. Zwicky at the California Institute of Technology on mosaics and on sodium chloride crystals, and the work in Chicago by Dr. Bennett on the effect of an electric field on the arrangement of paraffin crystals are worthy of notice.

There have been numerous important and interesting engineering developments during the past year.

LIGHTNING RESEARCH

As the result of the investigations of natural and artificial lightning carried on at a number of field stations in various parts of the country, it has been pretty definitely established by the use of the cathode ray oscillograph that most outages and damage to transmission lines are the result of direct strokes rather than induced lightning. Two records during 1930 were obtained of crest values of 4,500 and 5,000 kv. The latter value was recorded at a distance of several miles from the stroke. At the place of flashover it is estimated that the potential was at least 10,000 kv. It has been concluded that a lightning stroke to a ground wire, if flashover does not take place, does not result in a surge over the line. By using proper precautions it is believed, as a result of these lightning investigations, that it will be possible to build transmission lines which will be practically immune from lightning.

There have been developed and placed on the market during the year, two new types of lightning arresters, namely the thyrite arrester by the General Electric Company and the new porous block autovalve arrester by the Westinghouse Elec. & Mfg. Co. These arresters have characteristics which are considerably superior to their predecessors.

The commercial development and application of new types of discharge tubes have been very active recently. It seems evident that these devices are going to occupy a very large place in the control and conversion of power.

RADIO

In connection with radio there have been developed and put into commercial operation, 200 kw. transmitting tubes for broadcast stations.

Mercury-glass three-phase rectifiers have been developed to supply plate current for these high power radio tubes. These rectifiers are rated at 10,000 volts and 30 amperes. Additional grid-controlled gaseous discharge tubes, namely, the Westinghouse grid glow tubes and the General Electric thyratrons which are similar in their characteristics, have been developed during the year, the larger sizes being able to handle 75 amperes at voltages up to 1,000 or even 2,000. A grid energy of ½ watt or less is required.

Many new applications for grid glow tubes have been made recently. Among them is the theater light dimmer system which is controlled by very small rheostats which regulate the voltage applied to the grids of the tubes. These tubes supply rectified alternating current to choke coils which are saturated by the pulsating current, thus changing the inductance and controlling the lights. The small control wires can be led to any desired location, thus concentrating the control and simplifying the operation of the system. There are no moving parts and contacts, except for the small control rheostats. A very great advantage of this type of control is that the whole lighting program for the evening may be preset.

MISCELLANEOUS

A new stroboscope called a stroboglow has been developed, which illuminates a moving object for a period of only 3/10 of a microsecond or less. This interval is so short that an object moving at seven miles a minute appears to be perfectly stationary with no appreciable blur. No moving parts are necessary and no connection between the stroboglow and the moving object is required. The instrument is calibrated for frequency and may be used to determine the speed of rotation of the illuminated object.

A very small tube rectifier has been developed, rated at 3/10 of an ampere and 5,000 volts. This rectifier is 4½ in. long and 1¼ in. in diameter. It can be operated satisfactorily up to 10,000 volts and under special conditions, has been carried as high as 30,000 volts. These tubes are particularly suited for airplane radio transmitters.

A new oscilloscope with a linear time axis has been developed which employs a new type of cathode ray tube for its essential element. This oscilloscope has the advantage over previous types in that it has a larger field and the illumination is very much greater, making it possible to observe recurrent phenomena in a well lighted room. Non-recurrent phenomena lasting for a few microseconds, can also be observed readily for qualitative results. For recurrent phenomena the cathode beam may be synchronized so that the image appears stationary.

An automatic traffic control system has been developed and put into experimental use on main highways, using a beam of light crossing the side streets. When a car or other vehicle approaches the main highway on the side street, the beam is intercepted, thus causing a photocell to act giving the minor street the green light.

There has been developed in Germany another application of the light sensitive devices for the purpose of stopping railroad trains. Light from the headlight of the locomotive is reflected from a mirror on the semaphore and returns to photocells on the locomotive, which when illuminated operate the automatic stop mechanism.

There has recently come into general use in this country the electric photo-flash lamp which was developed in Germany and is used as a substitute for flash-light powder. The bulb contains a quantity of aluminum foil in an atmosphere of oxygen. A small filament, when heated electrically, causes the aluminum foil and oxygen to combine with an intense illumination. The elimination of noise and smoke is greatly appreciated by the average audience.

Studies and applications of piezo electric quartz crystals have been continued at Wesleyan University. By means of the cathode ray oscillograph, the rate of dying away of the oscillations of these crystal resonators has been studied. It has been found that a 600-kilocycle crystal started vibrating and left to itself, makes 60,000 vibrations before its amplitude falls to 1 per cent of its initial value. Various types of mountings for the crystals as well as the effect of the shape, cut and material of the crystal itself are being studied. A determination of the viscosity of quartz as a function of frequency is yielded by the above measurements. The coefficient of viscosity or quartz is approximately five at 600 kilocycles as contrasted with 500 for aluminum at 60 kilocycles and with values of the order of 10^8 ordinarily quoted for the low-frequency viscosities of metals.

A very accurate clock developed by the Bell Telephone Laboratories was exhibited at Cleveland last December, which is unique in that it is controlled electrically by a spherical quartz crystal.

The Stevens Institute of Technology reports the development of a clock which is automatically corrected by the standard radio time signals.

The limitations and advantages of commutation and current collection in hydrogen have been determined by laboratory and commercial experiments. In general, in the hydrogen atmosphere there results a lower contact drop. Satisfactory operation and long life are obtained if sparking is kept low. If appreciable sparking is present the humidity must be kept low.

The application of the helical groove to slip rings and commutators has been developed and applied commercially. Under severe conditions of commutation and current collection this apparently reduces brush wear and improves the electrical operation by reducing the formation of local hot spots; also better distribution of current between parallel brushes results.

A sample of commercial hipernik (a 50 per cent nickel-iron alloy) has been obtained having a maximum permeability of 167,000. Test samples from other castings have given as high as 13,000 for initial permeability and upwards of 400,000 for maximum.

Work during the past year on the fundamental nature of arcs and their extinction has given a greater insight into the problem of circuit interruption and is having a very definite effect on the design of circuit breakers.

There has been developed a non-destructive magnetic weld test meter for use with butt welds, which shows some promise commercially. For a given type of weld and a definite kind of steel, comparative results on welds are quite reliable.

At the Naval Research Laboratories interesting work has been done using the radiographic method for detecting imperfections in large steel forgings. Ordinary X-rays can penetrate only three or four inches of steel, but by the use of radium it has been possible to obtain photographs through twelve inches of steel. The radium has the advantage that it can readily be transported to the piece to be inspected and requires no complicated auxiliary equipment. If thick pieces of steel are to be photographed, however, either a long time must be used or a considerable quantity of radium or radium emanation must be available.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 8

The JOURNAL of the A.I.E.E. for August 1931

C. E. Skinner, *President*
F. L. Hutchinson, *National Secretary*

Publication Committee

E. B. Meyer, *Chairman*
W. S. Gorsuch F. L. Hutchinson
W. H. Harrison H. R. Woodrow

Publication Staff

George R. Metcalfe, *Editor*
G. Ross Henninger, *Assoc. Editor*
C. A. Graef, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in Electrical Engineering are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

REPUBLICATION from Electrical Engineering of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America.
Number of copies this issue—

24,000

This Month—

Front Cover

Emerald Bay—Lake Tahoe, California—where Pacific Coast conventioneers may spend pleasant hours between technical sessions.

Doctor Skinner Takes the Helm 633
A Message From the New President

Will Tuned Power Lines Solve Long Distance Transmission? 634
By H. H. SKILLING

Present Practise in System Grounding 638
An A. I. E. E. Committee Report

Engineering and Human Happiness 641
By W. S. LEE, R. V. WRIGHT, R. E. TALLY, H. H. PORTER, F. L. STUART

Has Man Benefited by Engineering Progress? 642
By C. E. KENNETH MEES

An A-C. Network for Portland, Oregon 644
By S. B. CLARK

Development of Gaseous Tube Lighting 648
By D. F. MOORE

Neon Tube Sign Lighting 650
By P. A. KOBER

The Propagation of Electric Waves 652
An A. I. E. E. Committee Report

Airplane Flight Aided by Electricity 654
By C. F. GREEN

—— Turn to Next Page

Desirable Accuracies in Instrument Transformers 657
By E. C. WENTZ

Mutual Impedance of Grounded Wires 660
By R. M. FOSTER

Burn-Off Tests in Low-Voltage Networks 662
By GEORGE SUTHERLAND and D. S. MacCORKLE

Transient Voltages in Auto-Transformers 664
By K. K. PALUEFF

An Improved Welding Generator 666
By J. H. BLANKENBUEHLER

A Telegraph Testing Machine 668
By F. B. BRAMHALL

Average-Voltage Method for Transformer-Loss Measurement 670
By ARAM BOYAJIAN

Insulation Research Advances Are Recorded 672

- **The Conductivity of Insulating Oils** 672
  By J. B. WHITEHEAD
- **Some Electrical Characteristics of Cable Oils** 673
  By HUBERT H. RACE
- **Fundamental Properties of Impregnated Paper** . . . 674
  By J. B. WHITEHEAD and W. B. KOUWENHOVEN
- **Air and Moisture vs. Paper Insulation** 674
  By J. B. WHITEHEAD and F. HAMBURGER, Jr.
- **Insulation Variability** 675
  By M. C. HOLMES
- **Thermal Breakdown of Solid Dielectrics** 676
  By P. H. MOON
- **Equivalent Circuits of Imperfect Condensers** 676
  By C. L. DAWES and W. M. GOODHUE

Water Power Exploitation in Switzerland 677

Short Items—

- **Konel—A Substitute for Platinum** 659
- **Suspension Insulator Lifts 20-Ton Load** 671

News of Institute and Related Activities 679

- **Local Institute Meetings** 692
- **Employment Notes** 693
- **Membership** 696
- **Engineering Literature** 697
- **Industrial Notes** 702
- **Officers and Committees** (For complete list see pp. 81-84, January 1931 issue of ELECTRICAL ENGINEERING.)

SWASEY gifts to The Engineering Foundation now total three-quarters of a million. (*See p. 689.*)

KANSAS CITY, host city to the Institute's fall meeting, offers the Kansas City Athletic Club as headquarters. (*See p. 679.*)

BOARD of directors sanctions Montana Section and considers other important questions at summer convention meeting. (*See p. 684.*)

DELEGATES attending the summer convention recommended that the board of directors provide for national and Section membership transfer committees. (*See p. 679.*)

TRENDS in the practise of power-system grounding based upon recent A. I. E. E. committee reports show a definite shift toward solid grounding. (*See pp. 638-41.*)

NEON lighting and other developments in luminescent gaseous tubes are reviewed historically and technically in two articles written by authorities on the subject. (*See pp. 643-52.*)

BURN-OFF characteristics of a-c. low-voltage network cables, exhaustively investigated through a series of field tests staged by a New York utility, are reviewed comprehensively in this issue. (*See pp. 662-4.*)

INSULATION research as reflected in recent Institute papers is reviewed in this issue (*see pp. 672-7*). Discussion offered at the recent summer convention reveals a decided difference of opinion as to the practicality of certain decisions reached through laboratory research. (*See pp. 683-4.*)

BENEFITS to civilization accruing from scientific and engineering advances are to be considered by eminent persons as a part of an ambitious publication program undertaken by The Engineering Foundation. (*See p. 689.*) The first of the proposed series of articles appears in this issue of ELECTRICAL ENGINEERING (*see pp. 641-4*); the editors will welcome comments, criticisms, and/or rebuttal.

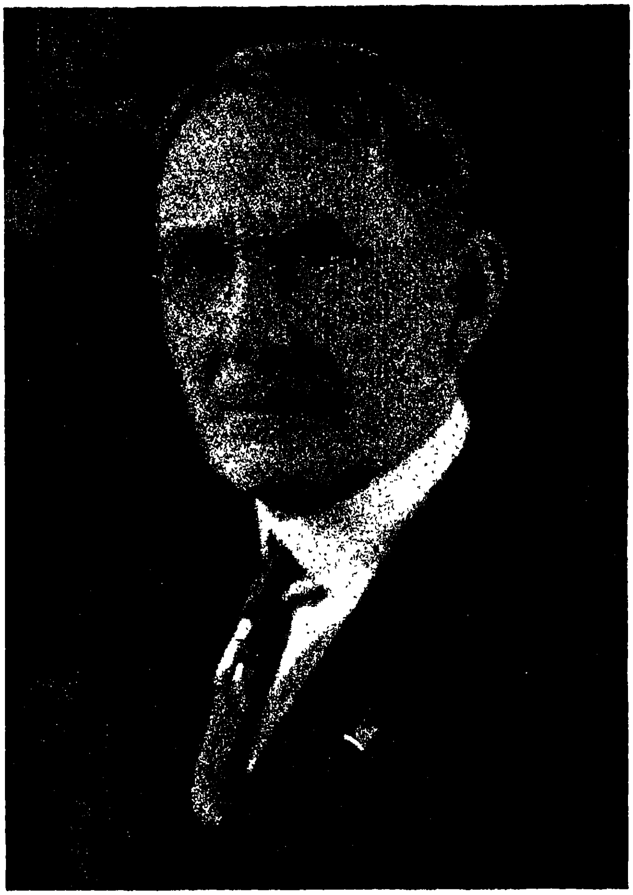
Doctor Skinner Takes the Helm

For the first time in his more than forty years of aggressive leadership in the electrical industry the Institute's new president takes a position vacated by another. Always he has pioneered, developing new processes, new departments, new products, new refinements; now he assumes leadership of the Institute. It is confidently to be expected that Doctor Skinner's pioneer spirit, keen foresight, and indomitable courage will prove invaluable to the Institute. His brief message follows.

FORWARD is the vital watchword, now as never before! We now are emerging from what perhaps is the most far reaching of the cyclic economic disturbances that have occurred during my forty-odd years of active service in the electrical industry. Far from being downcast, however, I have supreme confidence that we are at the beginning of an era even more significant in its possible advances than any that has gone before.

We are electrifying every industry. We may assume that the railroads are looking to electrification as one means of retaining transportation supremacy. Of profound significance is the fact that by far the most comprehensive railway electrification is being undertaken through a coordinated plan participated in by all parties at interest, including manufacturers and operators. Domestic application of electrical devices is only well begun and the next decade undoubtedly will see tremendous advances in this direction, releasing the household and farmstead from many drudgeries of the past and present. Thus, sketchily, we note that the electrical engineer is taking an ever increasingly important place in the affairs of the nation.

In all of this it is evident that the American Institute of Electrical Engineers has both a great responsibility and a great privilege to serve with increasing effectiveness its more than 18,000 members. To do this with a membership that is as diversified in its interests as it is far flung geographically, the Institute must go forward fearlessly, revising its policy and procedure as required to enable the best possible service to each individual member and each technical interest. Meetings must be arranged better to serve both the local and national interests of Branches, Sections, and Districts; publications must be developed to give to the specialist his detailed information and to the membership as a whole an accurate reflection of contemporary advances in the art and science of electrical engineering; members must be encouraged to participate more generously in Institute affairs; committees must be on the alert to develop their special fields. Progress in these directions already has been made; efforts under way must be pushed. However, in the final analysis, it is only through the loyal aid and wholehearted support of each individual member that real success can be achieved.



Charles Edward Skinner

A. I. E. E. president 1931-32

As for myself, I pledge my best efforts toward the advancement of the Institute in its many interests, and to uphold the best traditions of my illustrious predecessors. It is with confidence in the members of the Institute, confidence in the future of our industry, and confidence in the faith that the American Institute of Electrical Engineers can and will serve this industry ever more effectively, that I begin my term as its president.

CESkinner

Will Tuned Power Lines Eventually Solve Long Distance Transmission?

A new approach to an important problem in the field of electric power is offered by the author, who limits his discussion to the possibilities of tuned lines rather than their practical application. He presents the results of extensive research work, and on the basis of laboratory experiments points out that through the use of higher transmission frequencies, the efficiency of a given line might be increased as much as 500 per cent.

By
H. H. SKILLING
Associate A. I. E. E.
Stanford University,
California

LESS THAN 50 years ago when electrical engineering was young, there was vital and active interest in subjects which today are taken literally for granted. In early electric power work not the least of these was the question of choosing a desirable frequency for a-c. systems; 20 cycles, or 50, or 100? It was only natural that discussion pertaining to the frequency question considered principally the relative merits of different frequencies from the point of view of electric machinery—generators, motors, and transformers—with practically nothing said of the then simple subject of electric power transmission.

Thus it is that the large electric power networks of today find themselves definitely committed to certain frequencies earlier chosen for various expedient reasons. Now there is a definite trend toward the use of more and longer transmission lines for carrying large blocks of power from generation centers to load centers. In this connection the question of transmission stability is supreme; hence it is considered justifiable to reopen the question of desirable frequency, and to study it from the long lines point of view. It is well known of course that transmission characteristics of a given system may be improved by the use of frequencies lower than those now in vogue; but no general study of the influence of frequency has been published.

While the fundamental transmission line equations are:

$$E_g = E_r \cosh \sqrt{ZY}\, l + I_r \sqrt{\frac{Z}{Y}} \sinh \sqrt{ZY}\, l$$

$$I_g = I_r \cosh \sqrt{ZY}\, l + E_r \sqrt{\frac{Y}{Z}} \sinh \sqrt{ZY}\, l$$

where

E is voltage
I is current
g subscript, signifies generator end of lin
r subscript, signifies receiving end of line
Z is impedance per unit length of line
Y is admittance per unit length of line
l is length of line

it is most convenient to discuss transmission operation in terms of the general circuit constants:

$$A_o = \cosh \sqrt{ZY}\, l$$

$$B_o = \sqrt{\frac{Z}{Y}} \sinh \sqrt{ZY}\, l$$

$$D_o = \cosh \sqrt{ZY}\, l$$

$$C_o = \sqrt{\frac{Y}{Z}} \sinh \sqrt{ZY}\, l.$$

For ordinary transmission lines and for frequencies higher than about 10 cycles per sec., the value of factor $\sqrt{Z/Y}$ is practically constant and need not be considered as a function of frequency in this discussion. Hence the general circuit constants are proportional to the hyperbolic functions. However, if the resistance of the line in question is low compared with the reactance, and if the leakage from line to line is small, factor $\sqrt{ZY}\, l$ becomes purely imaginary and

$$A_o = \cos \sqrt{\mathbf{ZY}}\, l$$

$$B_o = j\, Z_o \sin \sqrt{\mathbf{ZY}}\, l$$

$$D_o = \cos \sqrt{\mathbf{ZY}}\, l$$

$$C_o = j \frac{1}{Z_o} \sin \sqrt{\mathbf{ZY}}\, l$$

[EDITOR'S NOTE: Bold-face symbols (**Z**, **Y**) indicate absolute values (magnitude only) time relationships as indicated by angles omitted.]

with $Z_o = \sqrt{Z/Y}$, the characteristic impedance of the line.

Thus it is made evident why low frequency gives good transmission characteristics. The desirable conditions are low voltage regulation under load, small charging current when lines are unloaded, and high synchronous stability. All three of these factors require a low value for B_o while synchronous stability requires also a value of A_o approximately unity. Both

---

From "Tuned Power Lines," (N . 31-124) to be presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, California, August 25-28, 1931.

of these conditions are obtainable with low frequency because Z and Y both are proportional to frequency, and as they decrease in value, the sine of $\sqrt{ZY}\,l$ decreases while the cosine of the same angle approaches unity.

Conversely undesirable transmission characteristics are encountered when the value of $\sqrt{ZY}\,l$ approaches $\pi/2$, because then the cosine approaches zero while the sine is near unity. Operation under such conditions is impractical because (1) regulation is so poor that with constant generator voltage the load is required to take practically constant current, (2) line charging current increases *indefinitely* as the receiving voltage rises, and (3) synchronous stability is possible only at extremely low power factor.

If the value of $\sqrt{ZY}\,l$ lies between $\pi/2$ and π, synchronous loading is quite impossible, but a static load may receive power. The static power limit (which is determined by voltage regulation and occurs at the load for which $d\,P_r/d\,E_r = 0$) becomes very large as $\sqrt{ZY}\,l$ approaches π, because $\sin \pi = 0$. For the same reason charging current to the line is very small; hence, transmission conditions are as good when the frequency makes $\sqrt{ZY}\,l = \pi$ as when the frequency is very low, except for the possible lack of synchronous stability.

An important point worthy of detailed consideration is that where the frequency used makes the value of $\sqrt{ZY}\,l$ slightly greater than π, and synchronous stability also is attained. The terminal steady-state conditions are identical when $\sqrt{ZY}\,l = k$ and when $\sqrt{ZY}\,l = k + n\,\pi$ with k representing any value of the function and n any integer. The truth of this statement for the idealized case under consideration is evident from the fundamental transmission line equations. The physical meaning is that transmission is good over a line the length of which is equal to a very small fraction of a wavelength of the transmitted voltage, and that it is equally good over a line the length of which is equal to a half wavelength or any multiple thereof. But this consideration includes only steady-state terminal conditions of a line without losses; certain modification is necessary before this statement may be considered to apply generally.

When line losses from resistance and leakage are not negligible it is best to use the hyperbolic-function form of general circuit constants. No change in the general understanding of conditions need occur, but the definiteness of the ideal line is lost; the power limit now is not infinite (as when $\sqrt{ZY}\,l = j\,\pi$) nor is synchronous stability either absolutely perfect or absolutely impossible. No longer is it quite true to say that $j\,\pi$ may be added to $\sqrt{ZY}\,l$ without changing terminal conditions. These things are nearly true, but not quite.

However, a point of far greater importance than line losses is the effect of terminal machinery. Even in the simplest system the general circuit constants will be modified by the generator, the transformers, and the load. If the apparatus at the sending end introduces a series impedance Z_1, and the receiving end apparatus introduces a series impedance Z_2, the general circuit constants become:

$$A_o = \sqrt{\cosh}\,\sqrt{ZY}\,l + \frac{Z_1}{Z_o}\sinh\sqrt{ZY}\,l$$

$$B_o = Z_o \sinh\sqrt{ZY}\,l + (Z_1 + Z_2)\cosh\sqrt{ZY}\,l + \frac{Z_1 Z_2}{Z_o}\sinh\sqrt{ZY}\,l$$

$$C_o = \frac{1}{Z_o}\sinh\sqrt{ZY}\,l$$

$$D_o = \cosh\sqrt{ZY}\,l + \frac{Z_2}{Z_o}\sinh\sqrt{ZY}\,l.$$

But if the line is long and the machinery is designed to have fairly low synchronous reactance, the only change in the constants that need be contemplated here is that a term must be added to B_o:

$$B_o = Z_o \sinh\sqrt{ZY}\,l + Z'\cosh\sqrt{ZY}\,l$$

where Z' is the total impedance of the machinery. This is an approximation, but it is almost true when the value of $\sqrt{ZY}\,l$ closely approximates π or is any multiple of π. It is not at all applicable if the value of $\sqrt{ZY}\,l$ approximates $\pi/2$, but it may be generally used because it applies whenever transmission characteristics are favorable.

Transient synchronous stability usually is investigated only after line and armature transients have died out; therefore as in the case of steady-state stability, only terminal line conditions are effective. A half-wavelength line would have the same order of transient stability as a low-frequency line except as the terminal machinery might be altered.

TRAVELING WAVES

The nicest description of the operation of a line is in terms of traveling waves. The generator may be considered as imposing on the line a series of electromagnetic waves which travel on the line to be more or less reflected from the receiving end, setting up a wave train traveling back toward the generator. Where the line is short a reflected wave returns to the generator so quickly after its initiation that it still is very closely in phase with the wave leaving the generator. Under this condition the voltages and currents of the two wave trains will add algebraically at the load end (assuming the load impedance to have the same angle as the characteristic impedance of the line) and differ by only a small angle at the generator end. Therefore, if attenuation is low the load voltage will be almost equal to, and in phase with, the generator voltage.

If the line be longer there will be a correspondingly larger difference in phase relation at the generator between the outbound and the returning wave. This involves trigonometric addition of effective voltages and currents at the generator and even with low attenuation, line regulation may be bad. However, if the line be of the proper length the reflected wave will arrive back at the generator just one cycle after its initiation there and consequently in phase with the next wave leaving the generator. Voltages and currents again will add algebraically and line regulation will be very good because the reflected wave will increase both end voltages equally. In this case as with the very short lines the load voltage will closely approximate the generator voltage (if attenuation is low) but 180 deg. out of phase.

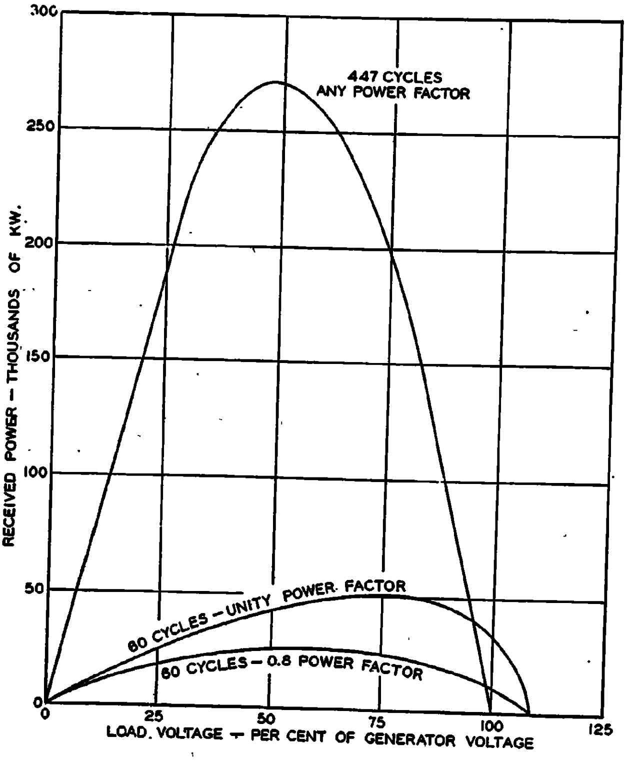


Fig. 1. Power limits of an operating 202-mi. 220-kv. line for normal 60-cycle operation and for suggested 447-cycle operation

The last few paragraphs have spoken of "long" and "short" lines. This refers to the electrical length of the line considering wavelengths rather than miles. However, a half-wavelength line is one for which the imaginary part of $\sqrt{ZY}\,l$ is $j\,\pi$, and hence it may be either a short line operating at high frequency or a very long line operating at normal frequency. Representative dimensions of a half-wavelength line are: 200 mi. long and 450 cycles, or 1,400 mi. long and 60 cycles.

The fact that apparatus at the ends of a line introduces impedance that increases the electrical length of the line already has been mentioned. It was shown that, approximately,

$$B_o = Z_o \sinh \sqrt{ZY}\,l + Z' \cosh \sqrt{ZY}\,l.$$

Since good transmission conditions demand that $B_o = 0$, it is desirable that

$$\sinh \sqrt{ZY}\,l = -\frac{Z'}{Z_o} \cosh \sqrt{ZY}\,l.$$

The hyperbolic cosine may be considered to be unity, either positive or negative. The lowest value of $\sqrt{ZY}\,l$ that approaches a solution of this equation will be between $\pi/2$ and π where the hyperbolic cosine will be negative and hence the values of frequency and length of line to be chosen should as nearly as possible make

$$\sinh \sqrt{ZY}\,l = +\frac{Z'}{Z_o}.$$

Consequently when terminal apparatus is considered, a shorter line or a lower frequency should be used than those given as representative in the preceding paragraph. If it is desired further to shorten the line or lower the frequency, more inductance may be introduced into the line, preferably in combination with static condensers across the line; this will result really in a section of "artificial line."

The presence or absence of synchronous stability for any given line may best be found graphically. Such methods, based on the circle diagram of the transmission line, tell at once the whole story of load limit, stability, regulation, and other factors. Although many statements in this paper now appear somewhat obscure in the light of the equations only, they become perfectly clear when the circle diagrams are studied. The diagrams unfortunately are too voluminous to be included, but Fig. 1 shows results obtained from such charts for a 202-mi. 220-kv. line having three 500,000-cir. mil cables spaced 15 ft. apart in a vertical plane; terminal apparatus not included. Under these conditions the value of sinh $\sqrt{ZY}\,l$ reaches a minimum at 447 cycles. Whether or not there might be synchronous stability at this frequency depends upon the synchronous machinery; it is probable that there would be. It may be seen that the maximum power per phase to be received at 60 cycles by a unity power-factor load is about 50,000 kw. Lagging power factors are much worse, and leading power factors are not much better. With transmission at 447 cycles the maximum power (if supplied to a static load or to an induction motor) obtainable is more than five times the 60-cycle limit.

The reason for the peculiar action of a half-wavelength line is essentially quite simple. The capacitance of the line is so balanced against the inductance of the line that the undesirable effects of both disappear. On an exact half-wavelength line with no losses and without load, with voltage maintained by a generator, the voltage at the receiving end would be equal and opposite to the voltage at the generator; in the middle of the line the voltage would be zero. The momentary charge at any point of the line would be proportional to the voltage; hence charging current would not need to be supplied from the generator, but merely would flow back and forth from one end of the line to the other each half cycle. Although there would be no current flowing at either end of the line, there would be a large current at the middle where the voltage would be low.

If load impedance were equal to the characteristic impedance of the line, current and voltage both would be constant along the line, but retrogressing angularly through 180 deg. The charging current would be passed on by each differential section of line to its neighbor as the voltage wave travels, finally to be used by the load.

If load impedance were less than the characteristic impedance, the current would be least at the middle of the line where the voltage would be highest. This resonant voltage rise is valuable because it makes efficiency and regulation of such a line better than could be obtained even from d-c. transmission; by proper insulation, reactance of the terminal machinery, and proper choice of the characteristic impedance of the line, resonant voltage rise may be prevented from becoming troublesome.

It is because of the interaction of the distributed inductance and capacitance that such a line is called a "tuned line." The similarity to a tuned radio circuit is striking.

As evidence that a tuned line will behave as predicted by the fundamental equations, power was transmitted at 60 cycles over a 1,468-mi. artificial line. The characteristics were those of the 220-kv. line previously described (which may be recognized as the Pit River line of the Pacific Gas and Electric Company, Calif.) and the potential used was 127 volts to ground, 0.001 of the real line voltage with a corresponding factor of 0.000001 for the power per phase as compared to the real line. The receiving end was arranged for loading with either a static impedance of any power-factor or with a single-phase synchronous motor. Extensive tests were made and the observed characteristics were found to be in close accord with the computed expectations; synchronous stability of the system was found to be exactly as expected. The half-wave-length line plus the reactance of the synchronous motor gave fair stability. The introduction of reactance into the motor leads was found to improve stability greatly, at the expense, however, of power limit. When the line was shortened to slightly less than a half-wave-length, it was impossible to keep the motor in synchronism; no synchronous power could be obtained although resistance loads continued to operate.

Fig. 2 shows reproductions of oscillographic records of voltages along the artificial line. Load impedance was somewhat less than the characteristic impedance of the line, and there was noticeable resonance. That the receiving voltage actually was lower than the sending voltage was due to the heavy load, the long line, and the unavoidable losses in the artificial line that do not properly represent a true line. Regulation would have been worse had the load been applied at an intermediate point.

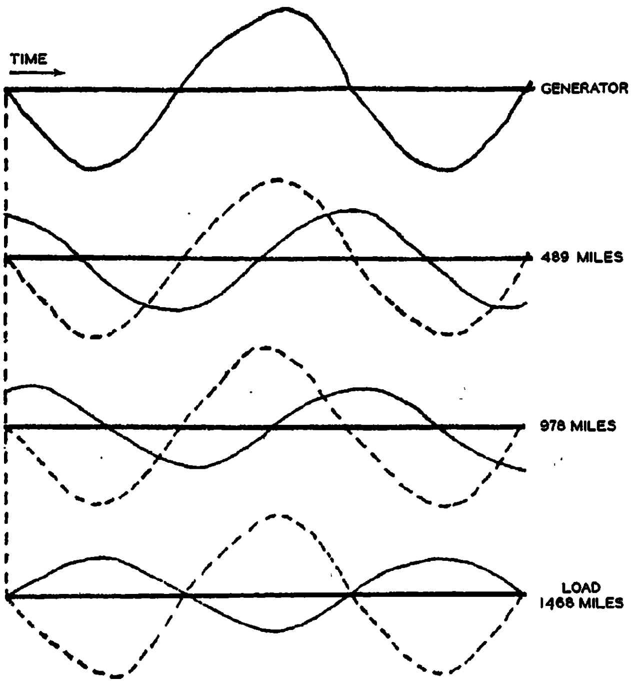


Fig. 2. Tracings from oscillograms showing voltage phase relations along a 1,468-mi. tuned line as compared with generator voltage (dotted)

While the subject of this paper considers the possibilities of the tuned line rather than its practical application and the details incident thereto, it seems quite reasonable to suggest that it is not at all impossible that 400-mi. transmission at 150 cycles will offer attractive economic possibilities. With the use of such a line of course motor-generator sets (probably induction machines) would be required for frequency-changing, but costly synchronous condensers would be eliminated. Even so considering the cost of building and maintaining 220-kv. lines it seems reasonable that even a relatively large amount of terminal equipment could be justified if it would eliminate one long line.

Bibliographic References

1. Tuned Power Lines, by H. H. Skilling; thesis, Stanford University, June 1927.

2. Characteristics and Stability of Transmission Systems, by F. E. Terman; thesis, Massachusetts Institute of Technology, 1924.

3. Power Limitations of Transmission Systems, by R. D. Evans and H. K. Sels, A. I. E. E. Trans., Vol. XLIII, 1924, p. 26.

4. Series Synchronous Condensers, by T. H. Morgan, A. I. E. E. Trans., 49, Jan. 1930, p. 162.

Present Practise in System Grounding

In this article are presented the principal findings of the Institute's joint interconnection subcommittee after canvassing 32 of the country's leading power companies. By comparing the results with those outlined in a similar report made in 1923, several noteworthy trends are indicated. Of particular note is a decided drift toward solid grounding.

TO OBTAIN A CROSS-SECTION of present day practise in grounding transmission system neutrals, the joint interconnection subcommittee of the power generation, protective devices, and transmission and distribution committees of the Institute submitted a questionnaire to 39 representative utilities throughout the United States; 32 replies were received. Data from these replies have been analyzed and condensed, and so far as possible are presented in this article in the form of tables and charts. In 1923 the protective devices committee through its subcommittee on grounding issued a similar report on the grounding practise of that day. Last year, however, it was felt that probably there had been sufficient change since 1923 to justify this second report.

The term "system" as used here may be defined as a certain number of circuit miles conductively connected; that is, connected by metallic ties. One company, therefore, may operate several systems, but on the other hand one system may overlap two or more properties. This designation is necessary because in the problem of grounding, the total mileage of the conductively connected transmission lines is of importance rather than the total mileage owned by any one operating company.

Methods of grounding adopted by the companies reporting are given in Fig. 1, which shows the longest single system and the average length of all the systems for each class of grounding. Where there are only two or three systems of one type they have been reported in full, since an average would not be representative.

METHODS USED ON SYSTEMS OF 110-KV. AND HIGHER

From the charts it may be noted that 93 per cent of the systems of 110-kv. and above are classified as solidly grounded, showing a marked preference for this type of grounding. Noteworthy deviations from this general practise are indicated as follow:

1. One company reports solidly grounded neutrals on its 132- and 66-kv. systems except at three substations, where from 53 to 75 per cent of the transformer capacity is grounded.
2. Another company grounds only one-third of the transformer capacity at one station, but the entire bank capacity at other grounding locations.
3. A third company reports using a resistance at the generating end of its 220-kv. system, but a reactance at the receiving end. This arrangement tends to decrease the angular swing between the two ends in case of a fault to ground, thus improving system stability.
4. Still another company is using an impedance grounding device in its most recent 220-kv. transformer installation.

There appears to be a tendency in the higher-voltage systems to limit the ground current by either impedance or resistance, or by a partial grounding of the total transformer capacity.

METHODS USED ON SYSTEMS OF 66-KV. AND LOWER

On systems of 66-kv. and less, the solid grounding practise is less prominent. As may be noted in Fig. 1, in this voltage range 51 per cent of the systems are solidly grounded, 9 per cent are grounded through resistance, 8 per cent are grounded through either reactors or grounding transformers, and 32 per cent have free neutrals. Of particular interest in this immediate connection are that:

1. Two companies report cases of reactance grounded substations operated in parallel with solidly grounded substations. This is done to obtain the desired distribution of fault current through the two or more grounding locations. Grounding a small transformer solidly obviously may be the equivalent of grounding a large transformer bank through an impedance so far as ground current distribution is concerned.
2. Another company reports the use of a Petersen coil. This report shows a marked reduction in the number of lightning interruptions during the year in which this coil has been in service.

In the case of the 11- to 14-kv. systems, an almost universal practise is to ground only one generator on each bus section. Four companies report grounding the generator bus sections through grounding transformers, while two use grounding reactors.

COMPARISONS BETWEEN PRESENT AND 1923 PRACTISE

In analyzing the results contained in this report E. C. Stone, who is responsible for the preparation of a major portion of the 1923 report, has drawn some striking comparisons between the two. One of these comparisons is shown in Table I.

From "Present Day Practise in Grounding of Transmission Systems," (N - 31-63) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931, and issued as the second report of the subject committee on grounding by the joint interconnection subcommittee of the power generation, protective devices, and transmission and distribution committees—F. C. Hanker, chairman. Personnel of subject committee on grounding:

C. A. Powell, chairman,
G. M. Armbrust,
M. T. Crawford,
E. A. Hester,
J. A. Koontz,
W. W. Lewis,
P. H. Robinson,
H. J. Scholz,
H. K. Sels,
H. H. Spencer,
E. R. Stauffacher.

TABLE I—COMPARISON OF PRESENT AND 1923 METHODS OF TRANSMISSION SYSTEM GROUNDING

	Present report		1923 report	
Method of grounding	Mileage	% of total	Mileage	% of total
Ungrounded	5,310	9.3	6,385	20.4
Solidly grounded	42,300	74.5	18,375	58.5
Resistance grounded	6,346	11.1	6,448	20.8
Reactance grounded	2,903	5.1	100	0.3
Total	56,859	100.0	31,308	100.00

While no radical changes in practise have been observed, some interesting trends are noted. The second report covers a total of nearly 57,000 mi. of transmission lines, as compared to about 31,000 mi. covered in the 1923 report. With the exception of approximately 5 per cent of the total mileage which is reactance grounded, all of the increase in mileage covered by the second report is solidly grounded.

In continuing Mr. Stone says that the present report clearly indicates a better understanding of the principles of system neutral grounding, of the fields for application of the various methods, and of the results to be expected. The points at which the neutral is grounded must be sufficient in number and so located as to permit adequate current flow regardless of the fault location. At the same time the neutral ground current must be limited to values which will not cause undue damage at the point of fault, and which will not produce system instability.

In discussing differences in grounding practise between systems operated at generated voltage and those operated at higher than generated voltage, Mr. Stone says in part that "of the 36,000 mi. of line reported on as operating at 34 kv. or above, approximately 34,000 mi. or 90 per cent are solidly grounded, while for the 21,000 mi. operated below 34 kv., only 55 per cent are solidly grounded. There are definite reasons for this difference in practise: on the high-voltage lines solid grounding gives greater benefits from the insulation standpoint, while at the same time the ground currents in relation to system capacity are relatively low; on the lower-voltage systems the fault ground currents are relatively large and the insulation benefits from solid grounding relatively small."

Mr. Stone expresses the belief that further analysis of the data will show that while the over-all grounded-neutral impedance may be lower than before, ground fault currents are still limited in value by the sectionalizing of the generating station buses. Thus a larger element of line impedance is introduced into the ground fault circuit than has been the case heretofore.

GROUND-WIRE PROTECTION AND TOWER FOOTING RESISTANCE

Over-all practise in the use of ground wires for the protection of transmission lines is shown in Fig. 2.

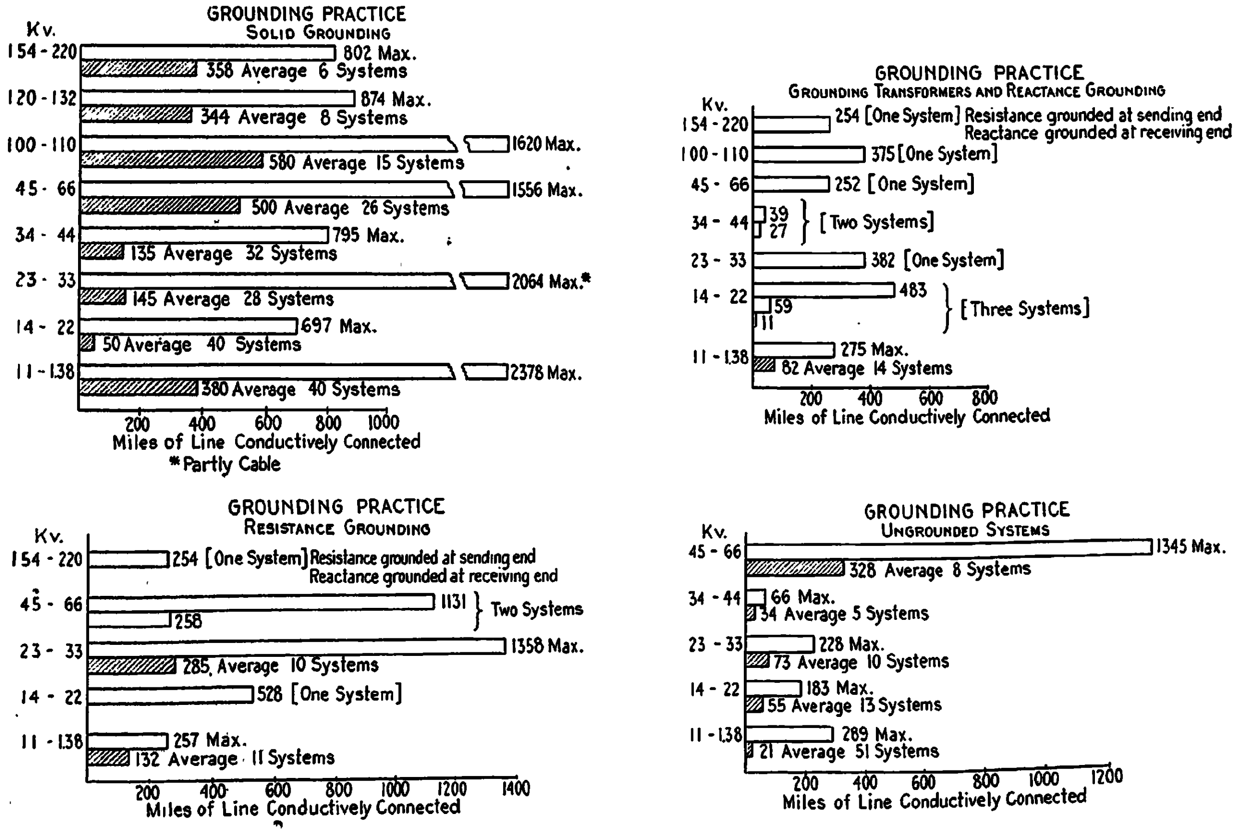


Fig. 1. Graphical summary of present day system grounding practise for different voltage ranges

In this graphical summary two different percentage bases are used as follow:

1. The total length of all lines reported in a given voltage class is taken as 100 per cent, and the mileage of lines protected by ground wires computed as a percentage of that total.

2. The total mileage in a given voltage class of each individual company is taken as 100 per cent, and the mileage of protected lines expressed as a percentage of this total. Averages of these percentages for each voltage class are the values given in the chart.

The former gives the practise of the country as a whole; the latter tends to show the opinion of transmission engineers better than the first value, perhaps, because the short systems are given the same weight as the long systems.

In protecting a line against direct lightning strokes, performance of the ground wire depends upon its receiving the direct strokes and conducting the energy to ground without causing flashovers to the line conductors. This depends upon the ability of the ground wires to remain at a low potential, which in turn is dependent largely upon the tower footing resistance.

Replies to the question regarding tower footing resistance, however, indicate that but few accurate data are available. Hence no average figures of any value can be given either on the basis of general territory or nature of soil. One company reports a range of from 1 ohm to 58 ohms over a restricted territory. The extremes reported by the seven companies replying to this question are 0.05 ohms and 300 ohms; the average 22.5 ohms.

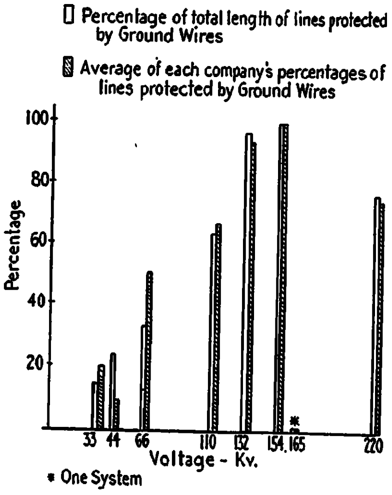


Fig. 2. **Graphical summary of present day practise in the use of ground wires**

SIMULTANEOUS FAULTS AT DIFFERENT LOCATIONS

In reply to the question, "do you have evidence of simultaneous faults at different locations," 25 replies were received. Of these, sixteen companies report no evidence; two report less than 1 per cent; three report 1 per cent; one reports 5 per cent, and three give replies as follow:

1. One company reports having trouble on a 300-mi. 66-kv. system until it was grounded. The neutral was found to shift to 80 per cent of the line-to-ground voltage at the middle of the section when one conductor was grounded.

2. A second company reports no evidence of simultaneous faults on their 132- and 220-kv. systems. One 66-kv. and two 22-kv. systems show 1 per cent or less, one 66-kv. system, 15 per cent, eight 26-kv. and three 13-kv. systems (mostly overhead) show 33 per cent, as indicated by relay operations.

3. A third company operating an ungrounded system reports conclusive evidence of arcing grounds without stating any figure for this type of fault.

In all cases, the evidence was taken from relay operations or from automatic oscillograph data.

In discussing this phase of the report Mr. Stone says that double simultaneous faults at different parts of a system are of particular importance because of the difficulties in many cases of providing relaying to isolate such faults without service interruption. Naturally in an ungrounded system simultaneous faults are charged to arcing grounds. In a properly grounded system arcing grounds should be impossible so that simultaneous faults here may be assumed to be the result of the rise in voltage on two phases when the third phase is grounded. The question then arises as to whether a relatively small reduction of fault voltage by lowering the ground impedance will correct the situation, or whether the insulation should not be sufficient to withstand these excess voltages for the short periods required for relay operation. The solution to this perplexing problem does not seem to be in reducing the impedance of the neutral ground circuit but rather in raising the system insulation to a level which will permit it to withstand the overvoltages prescribed by standard A. I. E. E. tests.

TYPES OF FAULTS

Regarding the division of the faults into the four classes, (1) one conductor to ground, (2) two conductors to ground, (3) phase-to-phase short circuit, and (4) three-phase short circuit, 27 replies were received. These are given in Table II as percentages of the total number of faults. The figures listed include both overhead and underground lines.

GROUND CURRENT AND RELAY OPERATION

All companies except two report sufficient current for relaying purposes. In these two exceptions a lack of proper selectivity was encountered at times of light load. Loss of synchronous load caused by ground faults is rare; only seven companies report having experienced this occasionally, while one company reports making changes in its relay equipment to rectify this difficulty.

TABLE II—DISTRIBUTION OF DIFFERENT TYPES OF FAULTS ON 27 SYSTEMS

	One cond. to ground	Two cond. to ground	Ph.-to-ph. short circuit	Three-phase short circuit
Maximum	97	45	54	36
Average	69	14	11	6
Minimum	30	0	0	0

In concluding his discussion Mr. Stone says that the problem of system grounding is only one phase of a greater general problem facing power engineers today—that of reducing insulation failures. However, because of the extensive research in progress, and of the definite advances being made, he urges an optimistic point of view on this subject.

Engineering and Human Happiness

By

W. S. LEE — President* A. I. E. E.

ROY V. WRIGHT — President A. S. M. E.

ROBERT E. TALLY — President A. I. M. E.

H. HOBART PORTER — Chairman Engineering Foundation

FRANCIS LEE STUART — President A. S. C. E.

THROUGHOUT THE AGES man has dreamed of relief from toil, of the bountiful supplying of his needs, and the attainment of comfort and luxury. He has struggled toward an ideal state in which these satisfactions might be enjoyed by all. From their beginnings the literature of all peoples has contained many expressions of man's aspiration for the "better life." Since happiness ever has been a condition earnestly desired by human beings the time seems propitious to ask—what has engineering done for humanity's progress toward this objective? What have engineers by their applications of scientific knowledge, by their control of nature's forces, by their improved and ever increasing utilization of new raw materials, or by their salvage of former wastes accomplished for the good of mankind.

For two years Admiral Byrd maintained 82 men under the most inhospitable climatic conditions to be found on earth! And they were comparatively comfortable and were happy in their adventurous enterprise. In contrast to the utter isolation of earlier exploring parties is the striking fact that throughout the period, persons in America and other regions thousands of miles away talked with him easily. Millions of men in all civilized countries daily heard by radio or read in their newspapers of the achievements, the dangers, the sports of this intrepid band.

On May 12, 1931, Capt. Frank M. Hawks flew from London to Berlin, arriving there ahead of a telegram despatched coincident with his start. On July 2, 1931, Gatty and Post completed in less than nine days a trip around the world. Startling exemplifications of engineering developments, these, and yet readers of morning newspapers hardly so much as wondered at the feats.

Daily, on the tables of millions of Americans of modest incomes are to be found articles of diet brought at low cost from places near and far by the most efficient transportation facilities the world ever has possessed. In the area known as continental U. S. A. perhaps as many as two million savages formerly sustained themselves precariously by hunting, fishing, and the crudest of agriculture. Within the same boundaries some 60 times as many human beings now possess means for supplying all their needs abundantly, together with many comforts and luxuries to say nothing of export. These multitudes also have facilities for education, many fine collections of art, and vast riches of other kinds such as even the kings and nobles no longer ago than when our grandfathers were boys could not have commanded.

Yet these items mention only a few examples of the many benefits which science, engineering, and chemistry have made possible within a half century to and through industry and commerce. How came these things to be looked upon as being so commonplace?

---

*Retired from office July 31, 1931.

An introduction to a series of articles in the course of preparation under the sponsorship of The Engineering Foundation. Not published in pamphlet form.

Modern man has come to accept as matters of course, one after another: unfailing supplies of good water conveniently delivered; sanitary disposal of sewage and refuse; more and better artificial light; steadily cheapening power conveniently applied; greatly improved facilities for communication (some of them almost instantaneous over long distances); better built and better equipped houses and working places; many means for rapid and enjoyable individual travel; commercial transportation remarkably low in cost and not only speedy, but also capable of carrying many commodities not formerly transportable; high explosives safe and convenient for many uses; recording devices that include besides the printing press, the camera, the phonograph, the "talking" film, and almost innumerable equipments and methods for special purposes; machinery for preparing and preserving foods in great variety; machines for making all forms of clothing and the materials therefor; novel equipment for entertainment and sports; farming implements; and tools of capacity, power, precision, and delicacy beyond the conception of persons unfamiliar with modern manufacturing.

These all are products of science, engineering, and applied chemistry, given to mankind through industry and commerce. It is of particular importance to note well also that progress made by science and engineering is ground *permanently* gained, a place from which to "take off" for further advances. Standards of living constantly are being elevated.

However, even the engineers, chemists, and industrialists who have provided present day society with its astounding equipment have given relatively little thought to the deeper effects of their achievements toward the lives and characters of men and communities and peoples. Of the painful present effects of individual and concerted neglect of immaterial (or spiritual) consequences, Progress is demanding a reckoning. Capacity to produce has been achieved; and the ability to discover and develop more and better goods and services made part of the world's present equipment.

But, how to divide the benefits of engineering progress properly has not yet been learned sufficiently well to permit maintenance through well ordered production, distribution, and consumption without disastrous fluctuation of enjoyment. Perhaps the methods of engineering and science could be applied beneficially to some features of this problem also, supplementing progressive business methods.

In an effort to effect a worthwhile contribution in this direction, The Engineering Foundation has invited an imposing array of highly qualified persons to comment upon various phases of the general subject of engineering developments' relationship to human progress and happiness. The first of these articles appears here; others are expected to eventuate.

Has Man Benefited By Engineering Progress?

A noted research worker, head of a modern laboratory, decides that the life of the future will simulate the life of the ancients; built, however, on a foundation of modern engineering.

By
C. E. KENNETH MEES Eastman Kodak Co.,
Rochester, New York

IN CONSIDERING the fundamental problem of whether engineering progress—under which term the engineer probably will modestly include the development of science and the arts through the ages—has been on the whole a benefit to mankind, it is necessary first to define what is meant by "benefit." This involves a consideration of the aim or purpose which may be ascribed to man's life on the earth.

This aim depends upon the person ascribing. The biologist probably would say that that purpose was the reproduction of the species; the mystic that the chief aim of man was to worship and glorify his maker; the materialist that it was to achieve happiness; while the Greek philosopher would say that it was to increase his knowledge of good. In considering the effect of scientific progress through the ages, therefore, one must consider its effect upon each one of these aims as well as upon any others which may occur to him.

If the purpose of the race is to multiply the species, then engineering progress certainly has been successful, since the population of the world is increasing rapidly and promises to become a very great problem in the near future.

To the mystic, the advance of civilization seems to offer no consolation. If man is more ethical than he used to be, he certainly is becoming less religious, and whatever future developments may show, at present engineering can claim no triumphs in the field of religion.

This leaves only the last two categories: the acquisition of happiness by the individual, and his progress towards a knowledge of good. It is under these two headings that my colleagues would think that engineering progress has been of benefit to mankind, including under the heading of *happiness* all the material benefits

---

First of a series of articles written expressly for The Engineering Foundation and released to ELECTRICAL ENGINEERING for publication. Not available in pamphlet form.

which it has conferred, and under the heading of *good* all the cultural and intellectual benefits.

Happiness, however, is not a thing which depends upon the possession of material things beyond a certain minimum. Happiness depends only upon the spirit, provided that spirit is not oppressed by the material situation of the body; it is fundamentally a by-product of activity of some kind. A man can be happy in arduous toil or in nerve-racking sport; he can be happy in intellectual relaxation; he can be happy, passively happy at any rate, in mere contemplation. Has not almost everyone heard of contented cows?

The one great gift of science to the world has been the diminution of disease. Diseases due to microorganisms, especially those which afflict the young, are diminishing rapidly as a result of the exploration of their natures and an application of the discoveries made. In their turn diseases due to deficiency are being diminished and eventually will be destroyed. One may look forward without doubt to a world in which widespread pestilences can exist no more. This certainly is a benefit to man which may be claimed by engineering.

But apart from this, I doubt if the life of the agriculturist in any country today is any happier than was that of a peasant in the Nile Valley 4,000 years ago. It is true that in the more advanced countries he has had great aid in his struggle with the pests that afflicted his crops and that in many cases as the result of applied engineering, he has had irrigation supplied, the first engineers to do this having lived more than 40 centuries ago. Moreover, in a few countries, and especially in the United States, machinery has reduced the heavy labor of the old-time farmer and has added many comforts to his domestic life. But, while machinery assisted the farmer at first, it now is undermining his status and perhaps may end by eliminating him. Hence the old normal life of man in which he cultivated the soil and lived on the crops, exchanging a small surplus for goods produced by somebody else, is passing possibly never to return. Engineering can produce that surplus and supply it to the consumer at a far lower labor cost than can the individual producer, and throughout the world economists and statesmen are considering the future of the farmer with troubled faces, remembering that farming is the normal life of man and that any other life for the mass of mankind involves tremendous readjustment in our whole economic and social system.

To turn from the agriculturist to the town dweller and even to the intellectual of the city, will any student of history agree that the inhabitants of an American city are any happier on the whole than those of a Greek or a Babylonian city of the past? This is a thing difficult to assess, but for myself, if I could exchange the life in a modern city for a life in Athens of the Periclean age or Thebes under the eighteenth dynasty, I think that undoubtedly I should accept it. In those days there was more leisure, more opportunity for the exchange of ideas, less pressure, and less emphasis on material things. There is little that a man can get today which he could not have had in Athens. It is better to walk a short distance than ride a long one. It is better to talk to one's friends and attend to one's business in a leisurely manner than to dash off to the office, returning in the evening tired. Life in a small city in a house with a garden is better, it seems to me, than is a life in the inevitable apartment of the large city. Perhaps it may be claimed that the urban worker has gained many comforts by the progress of engineering and that in recent years, at any rate, life in the sordid slums of our great cities has been mitigated by technical progress. It may be true that a factory operative in modern American textiles has a much greater chance of happiness than a corresponding operation in an Old World mill town of 70 years ago. But it seems to me that under those factory conditions of the first half of the nineteenth century the nadir of human existence was reached and that more properly the lot of the modern worker might be compared with the poorer classes of the great cities of the ancient world before the machines of the engineer had begun to replace the handwork of the craftsman. And I feel that a freeman of the Roman Empire, an apprentice of the middle ages, and perhaps even a Grecian Helot, had at least as good a chance for happiness as have most modern factory workers.

When one turns to the highest aim of mankind, that which we may define as progress in culture, it seems to me that the modern world is very much less satisfying than the world of the past. Culture primarily demands leisure, and at the present moment, at any rate, leisure is conspicuously lacking; it demands intellectual detachment, and intellectual detachment is exceedingly hard to accomplish.

Some of my colleagues may urge that engineering progress has contributed to international understandings; to this I would enter a definite objection. I doubt if nations ever have hated one another so fervently as they do at the present moment. Looking back on history, one can watch the waxing and waning of international good feeling; at the present moment it seems to me it is nearly at a minimum.

What then of the future? Shall scientific progress stop in an effort to get back to a world of the past? To this I should say that such discussion is futile. Scientific progress will continue and will be accelerated. In my opinion acceleration will end finally in a revolution of the whole social and economic life. What form that revolution will take and what type of life will come out of it, cannot be foretold, but I believe that in some respects the life of the future will be closer to the life of the past than to the life of today. I believe that a large portion of mankind will abandon the feverish quest for material things and will employ greater leisure for the development of art and the cultivation of its soul. This Utopia of the future may be possible primarily because of engineering progress, and in that sense engineering progress may be at some time a blessing to mankind. Up to the present time I doubt whether on the whole it has been.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

An A-C. Network for Portland, Oregon

An underground distribution system comprising duplicate 11-kv. primary feeders and an isolated network secondary system is adopted to supplement existing d-c. and radial 2.4-kv. systems. Provsion for burn-off is not made; special junction boxes were developed.

By
S. B. CLARK
Non-member

N. W. Electric Co.,
Portland, Oregon

IN COMMON with other utilities serving areas of relatively rapid load growth, the Northwestern Electric Company which serves portions of Portland, Oregon, recently was faced with the problem of congested underground feeders and the prospect of further load growth. To supplement the three-wire d-c. Edison system originally installed in 1914 to serve the downtown underground district, the company placed in service in 1920 several radial a-c. three-phase 2.4-kv. primary feeders, later networked for load transfer purposes. At the same time radial secondary circuits connected to duplicate single-phase transformer banks for 120-240-volt lighting, and to closed-delta banks for isolated power loads, also were installed. In 1930 the company completed further steps in its distribution system development, initiating an 11-kv. duplicate primary, 125-216-volt Y radial secondary distribution system differing in some respects from any system now in use.

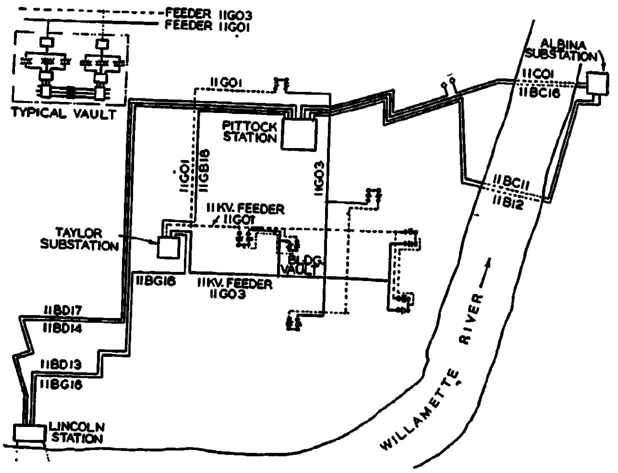


Fig. 1. 11-kv. underground distribution system of the Northwestern Electric Company, Portland, Oregon

In making the economic studies preceding the latest trend in the company's distribution practise, due consideration was given to the present a-c. and d-c. sectional load density and to capital investment in the existing distribution systems. Eliminating d-c. distribution as a factor in future demands, three types of a-c. distribution plant were considered, with capacities based upon anticipated load growth and costs estimated on each for purposes of economic comparisons. The three types were:

1. Expansion of existing 2.4-kv. three-phase primary network with radial single-phase and three-phase secondary circuits.
2. Expansion of existing 2.4-kv. three-phase primary along radial lines with four-wire 120-208-volt Y network secondary.
3. Installation of 11-kv. feeders with 125-216-volt Y secondary; the 11-kv. feeders to be (a) radial, (b) loop, or (c) duplicate.

Comparative cost data which influenced the final selection of system are given in Table I. All costs of course are based upon actual conditions peculiar to Portland, including the Pittock station's limited capacity together with its correspondingly large capital investment in 2.4-kv. station primary equipment and the large capital investment in a reliable 2.4-kv. distribution system, neither of which could be discarded within acceptable economic limits. Load forecasts indicated that the area of some 40 city blocks adjacent to the station eventually would develop a load demand equivalent to the existing capacity of Pittock station. Thus the development plan decided upon withdraws some of the longer 2.4-kv. feeders from sections outside that adjacent area, releasing station and feeder capacity for area use and picking up with the newer distribution plant the outside sections as well as extremely heavy concentrated loads within the adjacent area.

The cost data of Table I reveal the reason for the selection of the 11-kv. duplicate primary, 125-216-volt four-wire radial secondary for the Northwestern com-

---

From "A-C. Networks in Portland, Oregon," (No. 31-M2) to be presented at the A. I. E. E. Pacific Coast Convention, Lake Tahoe, Calif. August 25-28, 1931.

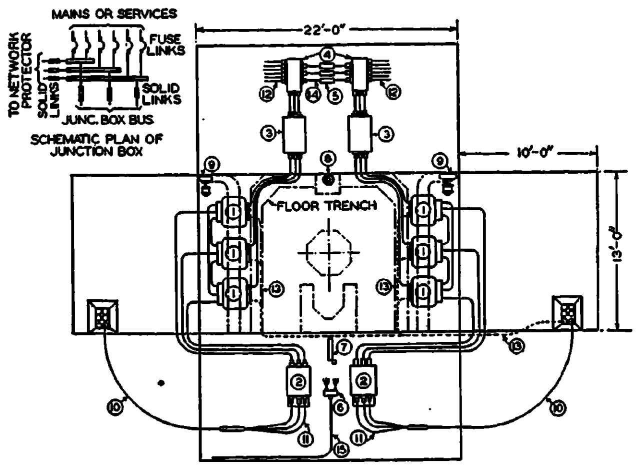


Fig. 2. Schematic arrangement of the floor and four walls of a standard 11-kv. underground vault

(1) 100-kva. 11,000/125-216-volt, single-phase transformers. (2) Three-position submersible grounding switch. (8) 1,200-ampere automatic network switch. (4) Four-way three-phase junction box. (5) Single-phase paralleling reactors. (6) Pilot-wire cable junction box. (7) High-water float and control switch. (8) Sump-pump float control. (9) Sirocco ventilating fans. (10) Three-conductor lead-covered 11-kv. cable. (11) Single-conductor lead-covered 11-kv. cable. (12) 240-volt mains to sec. network. (13) System neutral. (14) Junction-box bus. (15) Pilot cable.

pany's Portland underground system. The slightly better cost showing of the 11-kv. loop system could not be realized practically, because proper sectionalizing switches with pilot relays and control were not available from manufacturers without appreciable development work. In passing it should be noted that had existing conditions been more favorable to the adoption of a more compact system, there would have resulted appreciable reduction in costs per kva. as compared with those of Table I.

The general plans of the 11-kv. tie-lines between the Lincoln steam plant, Pittock station, and Taylor and Albina substations, as well as the tie-lines for the network vaults now in service, are shown in Fig. 1. The Albina substation is the general distribution point for the company's hydroelectric power. Three-conductor 250,000-cir. mil, 15/32-in. paper, type-H cable was installed as the standard 11-kv. feeder. As may be noted in Fig. 1, taps from each feeder cable are carried into each vault with no switching protection provided except station circuit breakers between the station bus and station transformers. Either three single-conductor 250,000-cir. mil or 350,000-cir. mil paper cables (three cables installed in one duct and paralleled where load conditions demand) were adopted as maximum standard for secondary mains.

The standard vault provided for in this system plan is 22 ft. in length and 16 ft. in width with 10-ft. headroom. They are designed to accommodate duplicate banks of three 200-kva. single-phase transformers, with the secondary leads from each bank networked within the vault. However, the installation of the 200-kva. units will be made only when and as required by heavy concentrated building loads fed directly from the vault. In many cases three-phase transformers could have been utilized more economically than single-phase unit, but space restrictions in many important locations precluded the use of the necessarily large manhole openings.

Removable cell walls are provided to separate the 11-kv. transformers from the rest of the vault. The transformers used are of standard submersible network type with special low-voltage windings for providing the 125-216-volt Y instead of the usual 120-208-volt Y service. Three 2.5 per cent voltage taps are provided for increasing secondary voltage and special insulated studs extending through the transformer casing are provided to permit the expedient evolution of a three-phase closed-delta bank in the event of an extremely heavy power load being encountered with factors unfavorable for connection to the four-wire system. All transformers have an inherent impedance of 5 per cent.

General details of vault design are shown in Fig. 2. Special grounding and other safety precautions have been observed and a special pilot-light signal system conveys information to the Pittock station operator revealing to him the open or closed position of the 11-kv. network protectors, the presence of high water, or dangerously high temperatures in cables or transformers. This pilot system eliminates the necessity of constant inspection for operating information and also serves as an automatic indication of network switch position when a feeder is taken out of service.

Table I—Comparative Cost Data on Distribution Systems

System	Construction costs		Carrying charges		
	Per installed kva.	Per effective kva.	Investment 14% per kva.	Energy losses per kw-yr.	Total
D-c. Edison	$137.00	$137.00	$19.21	$20.24	$39.45
2.4-kv. a-c. radial	101.00	101.00	14.15	5.00	19.15
2.4-kv. a-c. radial primary with network secondary	117.00	119.00	17.00	5.00	22.00
11-kv. radial primary with network secondary	77.00	78.00	10.80	2.20	13.00
11-kv. duplicate primary with radial secondary	68.00	70.00	9.50	2.20	11.70
with network secondary	79.00	81.00	11.10	2.20	13.30
11-kv. loop primary with radial secondary	67.50	69.00	9.45	2.20	11.65
with network secondary	78.70	80.00	11.00	2.20	13.20

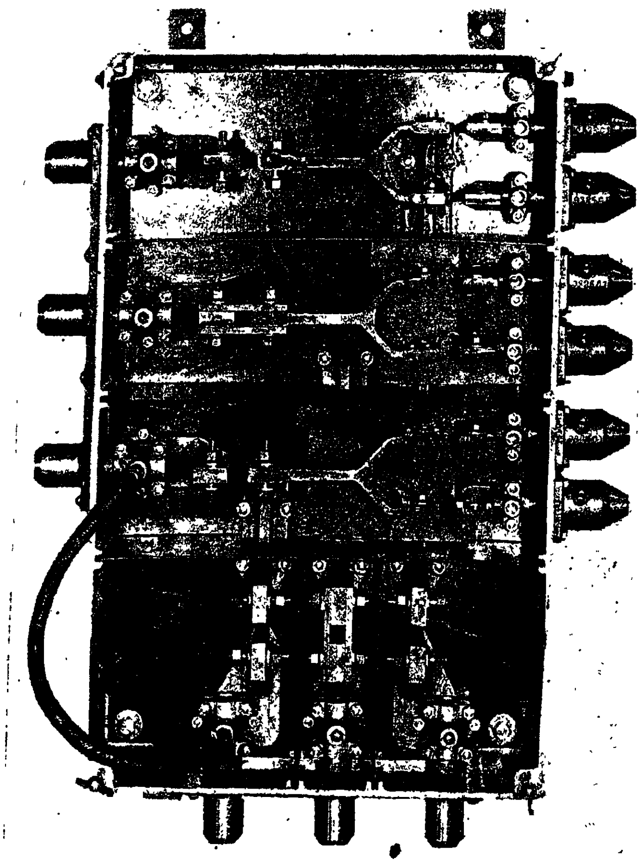


Fig. 3. Company's special design of junction box

During the study of existing network systems it became apparent that particularly along the Atlantic Seaboard, networks were being designed with an inherent ability to clear all secondary faults even at the expense of appreciable extra investment. However, on the basis of data available covering eastern operating experiences and construction costs, and on the basis of Portland operating experience which indicated that secondary faults rarely occur, it was decided that for the Portland system, additional capacity to provide for the burning clear of secondary-main faults was unwarranted. It was decided also that until results are available from wider operating experience, large solid-type networks should be avoided.

In view of the foregoing, and following the practise of some companies to insure against transformer damage or severe secondary cable burn-outs (especially where cables are mechanically injured) junction boxes were provided between network switches and outgoing conductors with both mains and services heavily fused. The first of these boxes to be installed were of standard manufacture and 1,200-ampere capacity; but the design did not prove to be entirely satisfactory. Thus a new design (Fig. 3) was developed and to date is assembled in the company's shop. The non-submersible case is of aluminum alloy (92 per cent aluminum, 8 per cent copper). Buses and terminals for the buses between boxes, and terminals for connection to network switches, have a normal rated capacity of 1,600 amperes, while the six terminals for main and service connections have a normal rated capacity of 600 amperes each. All unit parts are mounted on a separate practise of 1-in. ebony asbestos with barriers between conductors of opposite polarity. Buses are of single castings machined for linkage to network switch leads, junction box, connecting buses, and fuse positions to main and service leads. Submersible terminals are provided only for service and main connections to insure against moisture penetrating the paper insulation should the junction box become submerged. Where conditions require capacity for a heavy power load, and with a direct service into a building, power service is supplied from one junction box, while lighting service is taken from the other. Under these conditions the necessary reactance (item No. 5, Fig. 2) is connected in the buses between the two junction boxes.

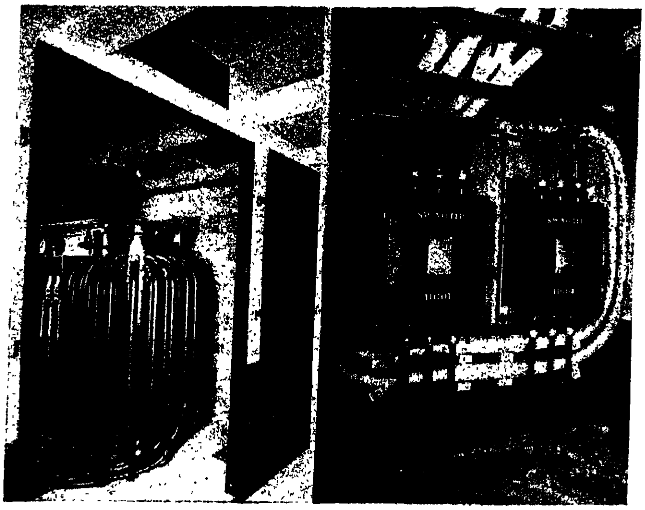


Fig. 4. 11-kv. basement vault construction

All new 11-kv. vaults are made waterproof in so far as possible, and without sewer connections although a small automatic sump-pump is provided to care for possible leakage. As ventilation becomes necessary a mechanical system of forced ventilation is installed. This ventilation system has been in use for some time on the 2.4-kv. distribution system, and includes a motor driven fan which discharges air through covered trenches in the vault floor, from which ducts lead into low metal cone housings at the bottoms of the transformers, thus forcing a thin sheet of air upward along each transformer casing, providing an effective and efficient means of cooling. The fan units are thermostatically controlled by transformer oil temperature, and as previously mentioned a high temperature alarm at the Pittock station is sounded by means of a contact-making thermostat in each transformer bank upon the event of dangerously high temperatures.

Vaults for 11-kv. primary, 125-216-volt Y secondary service often are placed within buildings, but under such circumstances cannot be standardized as readily as those in street areas, although of course certain identical features are retained. One example of a "near standard" is in service 64 ft. below street level in the subbasement of a department store. This vault is 25 x 27 ft. in plan with cell compartments for each transformer, and serves a demand of 775 kw. for lighting and 1,500 kw. for power.

The vault is supplied by duplicate feeders (Fig. 4 shows typical construction) each connected to two 450-kva. three-phase 11-kv./125-216-volt vault-type transformers connected delta on the primary and Y on the secondary. Secondary leads from each transformer feed through floor trenches to 1,600-ampere, three-pole open-type network protectors on one of the cell walls (Fig. 5). The load sides of the network protectors are connected to light and power buses suspended from the ceiling, the two buses being tied together by a smaller auxiliary bus to which the network mains from the street are connected. On this auxiliary bus, reactance is installed between the power and light buses to prevent objectionable voltage drop on the building lighting circuits.

In this installation all metering is accomplished by current transformers installed in the secondary light and power buses. Temperature and switch position indicators at Pittock station are provided as before mentioned, and telephone connection is provided between the vault, Pittock station, and the underground superintendent's office. Forced ventilation at the rate of 1,000 cu. ft. of air per min. serves to keep temperatures within desired operating limits. This building vault is networked through 1,600-ampere submersible network protectors to a street vault which contains six 150-kva. single-phase transformers with standard 11-kv. vault secondary connections.

The 11-kv. duplicate primary and isolated network secondary system has been in operation for several months, and to date no trouble excepting the necessary adjustment of network protector relays has been experienced. Three-phase motor operation has been entirely satisfactory on the four-wire system, even on the longer secondary mains. In cases where the d-c. or the three-phase a-c. power has been changed to the four-wire service, booster transformers to obviate any possible chance of voltage complaint have been installed in all cases where large ranges, bake ovens, lead melting pots, or other similar concentrated loads are encountered.

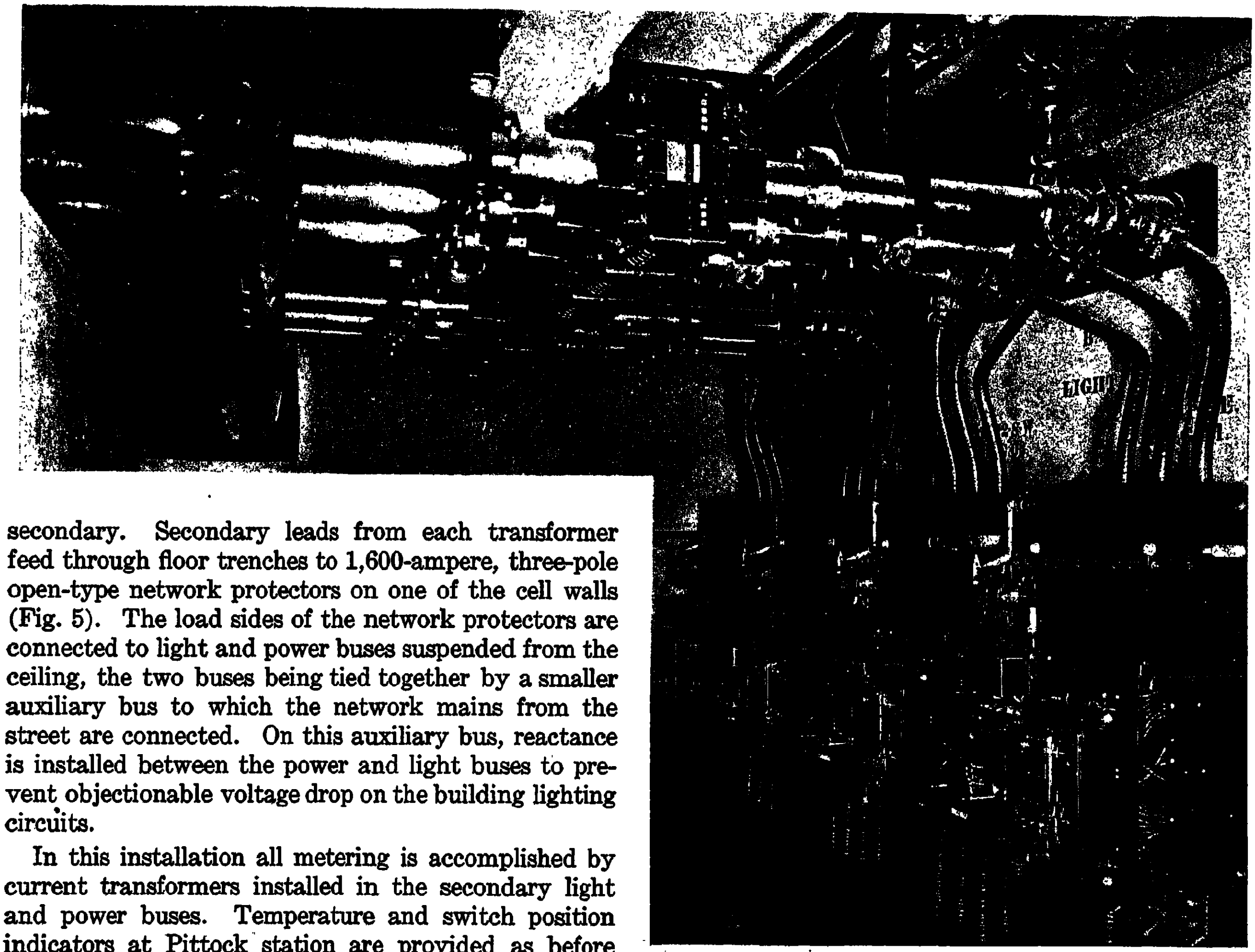


Fig. 5. Secondary construction in basement vault for store light and power service

Development of Gaseous-Tube Lighting

By
D. F. MOORE
Fellow A. I. E. E.

Consulting Engineer
East Orange, N. J.

Although what appears to be a multiplicity of different types of gaseous-conduction lamps have been developed, these are classified into a total of only sixteen groups. Outstanding developments in this class of lighting also are described in this article.

ALTHOUGH LIGHTNING represents a form of gaseous-conduction lighting which was observed by man millions of years ago, there are in practical use today only two general classes of gaseous-conduction devices. These two classes include (1) the non-luminous type—X-ray tubes, radio, and similar tubes, and (2) the luminous type to which this and the succeeding article are devoted. Although hundreds of devices in this second general classification appear to differ greatly in appearance and construction, they can be divided further into two general classes: (1) those of the positive column, and (2) those employing the negative glow. If each of these two classes is further subdivided into high- and low-voltage lamps, respectively, and these again subdivided into convenient groups, a total of sixteen groups of these lamps will result and under these practically all gaseous conduction tubes of the luminous type can be classified. (See accompanying tabulation.)

Perhaps best known among the various types of lamps are those of groups 1 and 9. Those of group 1, composed of script signs now popularly called neon signs, have grown so numerous during recent years that they have been said to "paint red the main streets of the whole world.". Those in group 9, of which the ordinary photographer's mercury-vapor lamp is a familiar example, came into use as early as 1895. Although at present these two groups are the most widely used of any of the sixteen, it should be borne in mind that any group at any time may assume increased importance.

The complete history of luminous gaseous-conduction lamps would read in much the same manner as that of many other outstanding developments of the present age. Like other developments, the present state of the art has been made possible only through a long period of research, many different investigators working independently and contributing to some one particular phase of the problem. It may be interesting, however, to note a few of the outstanding achievements.

An early (1905) script sign

What may be regarded as a starting point of the present development in script signs took place as far back as 1858. A glass tube smaller than a lead pencil had a platinum wire melted into each of its ends; after most of the air within the tube was removed it was touched to a high-voltage frictional machine and its interior immediately assumed a luminosity of pinkish hue. About a year later the air in the tube was replaced by pure gases, while fourteen years later a similar tube was lighted from an induction coil which in turn received its current from a primary battery. This type of apparatus persisted until about 1890, when efforts were initiated to devise a lamp of this type which would operate from a low-voltage house-lighting circuit. Continued and persevering effort along this line has resulted in the present state of development of the low-voltage lamps; many of the outstanding features mentioned in the following paragraphs are the direct results of such efforts.

Mercury-vapor tubes as mentioned previously were first brought out in 1895. These early tubes operated on low voltage but required momentary high voltage for starting the discharge. The next few years witnessed some accomplishment in other directions, and in 1899 tubes about 1¾ in. in diameter and about 8 ft. long, provided with external electrodes, were used to light a three-story factory building by tuning them to reso-

---

Written specially for ELECTRICAL ENGINEERING and based upon an oral presentation before the Illumination Group of the New York Section, A. I. E. E., March 8, 1931. Not published in pamphlet form.

Classification of Gaseous Conduction Lamps

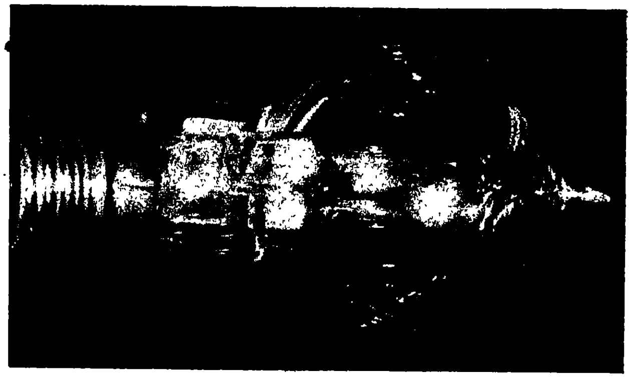
- **Gaseous Conduction Lamps**
  - **Positive Column**
    - **High Voltage**
      - 1. Script signs of the cold-cathode typ . These are in use now throughout practically the entire world, and are described in detail in the succeeding article.
      - 2. This group includes cold-cathod tubes from 1 to 250 ft. in length.
      - 3. Portable unit tubes of the cold-cathode type similar to those in groups 1 and 2.
      - 4. An ordinary incandescent lamp bulb of contemporary form with its filament replaced by a "gas filament" consisting of a fine-bore gas-filled glass tube.
      - 5. Tubes of the ordinary cold-cathode type used in a circuit tuned to resonate at the supply frequency.
    - **Low Voltage**
      - 6. Hot-cathode tubes designed to operate on low voltage without a special supply transformer. The electrode in this case is provided with a filament and associated circuit to reduce its potential drop. Tubes of this type can be modified for use on either a-c. or d-c. circuits.
      - 7. Tubes to operate on low voltage without a transformer or other potential-raising device. The main electrode is equipped with a small additional electrode; this electrode provides an electron gap which first functions on low voltage thus causing a long, positive column to form.
      - 8. Similar to group 7 except that bulbs of various sizes are used in place of tubes.
      - 9. Tubes in which the cathode electrode consists of mercury from which is produced the conducting mercury vapor.
      - 10. These are tubes with a cathode consisting of a steel button over which is compressed a heavy oxide coating for electron production, and penetrated by a small hole. These tubes constituted the first vacuum-tube rectifiers.
  - **Negative Glow**
    - **High Voltage**
      - 11. Tubes containing two parallel light-giving electrodes throughout their entire length.
      - 12. Bulbs with electrodes which when attached to a high-voltage circuit become surrounded with a negative glow.
    - **Low Voltage**
      - 13. Tubes with electrodes which shed corona light when attached to low-voltage circuits.
      - 14. Same as group 12 except that the gas content is neon. This is the commonly known "neon lamp" and can be adapted for television work by fitting it with two flat-plate electrodes about 2 in. square separated by a Crooke's dark space (about 0.01 in.).
      - 15. Cylindrical bulbs fitted with two internal cylindrical concentric electrodes. At the center of the inner electrode is a small cavity or crater which fills with an intense negative-glow light which projects itself from the end of the bulb only. The various sizes made require from 0.0001 to about 2.000 amperes.
      - 16. A bulb containing two tungsten-filament electrodes placed end to end with only a small space between. The light is due partly to corona glow, partly to incandescent tungsten, and partly to a tungsten arc. Usually these bulbs are charged with neon gas, but sometimes also contain mercury.

nate on a 25,000-cycle inductor generator used as a source of supply.

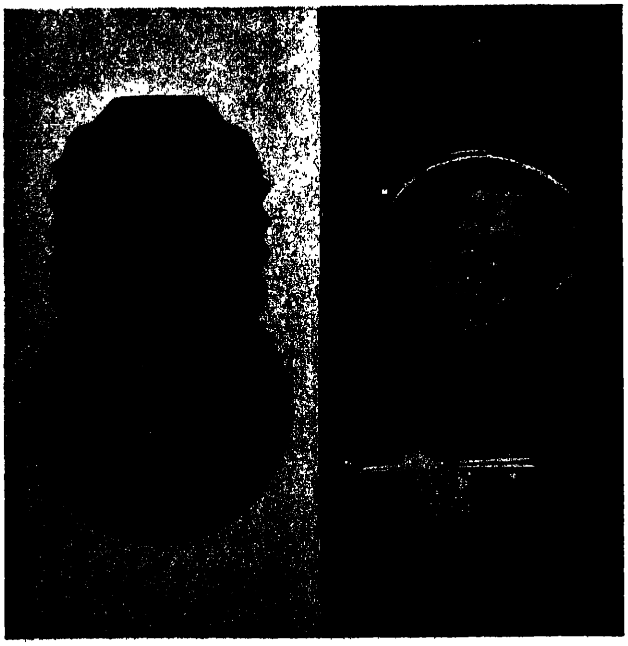
The year 1905 marked an important development in that the first script sign was put into use, and since that time the evolution of this type of light has been particularly rapid. The use in Paris in 1910 of nitrogen in a tube 150 ft. long marked one of these outstanding advances. Neon gas was introduced first into a bulb-type lamp with a gas filament in 1913. The significance of this step is too well known to require any further comment.

In 1915, however, an auto-thermic method of furnishing the carbon-dioxide gas then in common use was brought out; a lamp equipped with this device was said to give a perfect color value. Later this unit was made up with a 100-in. hairpin tube containing neon (exhibited at the New York Electrical Show in 1918) and its luminous efficiency was shown to equal that of the best incandescent lamp then available. Neon has found continued use through later developments right up to the present time not only for sign lighting but also for many of the other types of tubes and bulbs listed in the tabulation.

The future of gaseous tube lighting seems bright



A typical "gas-filament" lamp (group 4). Note that the metal filament is replaced by a fine-bore gas-filled glass tube



Two lamps of group 14. (Right) a television lamp; (left) an ordinary so-called "neon lamp" because its underlying efficiency, color, and intensity are all better than those possessed by the present solid conductor lamp. In addition manufacturers of solid conductor lamps today are resorting to inside frosting and exterior opalescent glass to increase the area of the light source; the gaseous tube possesses such properties inherently. That electro-luminescence will be "the light of the future," seems assured by recent advances which even now are causing the scientific world to expect still further developments.

Neon Tube Sign Lighting

The high-voltage cold-cathode neon tube as developed for commercial sign lighting is one of the few types of gaseous-conduction lamps to gain prominence. Their operating characteristics and associated transformer equipment are described in this article, and their advantages pointed out.

By
P. A. KOBER
Non-member

Claude Neon National Laboratories, Long Island City, N. Y.

IN THE DEVELOPMENT of neon sign lighting, great difficulties, and not a few, had to be overcome. As in other new developments, when the many obstacles encountered in the laboratory were surmounted, the additional problem of selling this new type of sign lighting to the public presented itself. That both difficulties were overcome is evidenced by the tremendous growth of the industry.

Although neon with its characteristic red glow was the first gas used for this type of lighting, a demand for other colors soon followed. Practically every color now is obtainable by utilizing the characteristic colors of other inert gases in clear glass tubing, and from mixtures of mercury and the inert gases in colored glass tubing.

Commercial neon sign lighting, however, as it is today, would have been delayed greatly had it not been for Georges Claude, a noted scientist of France. The value of his contributions, and particularly his success in the extraction, purification, and production of neon and other inert gases from the atmosphere, cannot be over-estimated.

NATURE OF GASEOUS DISCHARGE

Like the low-voltage gaseous conduction tube, the high-voltage tube belongs to the space-charge type, but differs from the former in that it may have either a positive or negative volt-ampere characteristic. The former is known as the arc; the latter as the glow discharge.

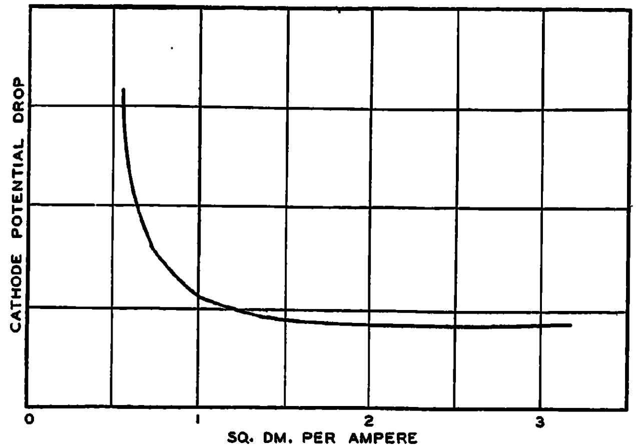


Fig. 1. Minimum cathode-drop characteristic for gaseous glow-discharge as obtained by Claude

No numerical values are given for the ordinate since these vary with different electrodes

In high voltage tubes of this type a high cathode potential drop exists which cannot be neutralized as is done in the hot-cathode type. This results in a certain amount of lost energy from which little or no light is obtained. Furthermore, this high-cathode drop, represented by a space charge consisting mostly of positive ions, tends to produce disintegration of the cathode by virtue of the relatively large mass and high velocity of these positive ions. In order to minimize disintegration by sputtering, and give a long-life tube, current values, electrode sizes, and gas pressures must be determined so as to keep the rate of sputtering sufficiently low; in other words, the mean free path of the positive ions must be decreased as much as other factors will permit, and the current per unit area of cathode must be made as small as possible. Claude has found that when the area of a cathode is in excess of 1.5 sq. dm. per ampere, the cathode drop reaches a minimum value (see Fig. 1).

Further explanation in regard to sputtering or disintegration of electrodes will not be amiss since, barring mechanical or electrical defects,* this phenomenon

---

Written specially for ELECTRICAL ENGINEERING and based upon an oral presentation before the Illumination Group of the New York Section, A. I. E. E., March 3, 1931. Not published in pamphlet form.

largely determines the life of the tube. The sputtering of electrode material forms a thin metallic film on the inside of the tube near the electrodes. It is known also that sputtering occludes the gas of the tube and thus diminishes the gas pressure, thereby increasing the mean free path of the positive ions. Since sputtering is caused primarily by the positive ions the net result is a cumulative increase in the tube operating voltage and also in the sputtering effect on the cathode. Finally, the voltage required to operate the tube becomes greater than that supplied by the transformer; at this point the sign begins to flicker and eventually goes out. The tendency to sputter varies with different metals but appears to be related to the latent heat of fusion, specific gravity, affinity for oxygen, and a number of other physical characteristics.

TRANSFORMER CHARACTERISTICS

To operate long tubes of small diameter obviously necessitates the use of a step-up transformer, since for the longest tubes an open circuit potential of about 15 kv. is required. With this high voltage, as might be surmised, many difficulties had to be overcome; principally those concerned with insulation.

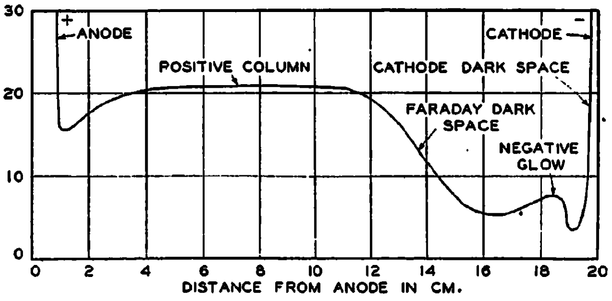


Fig. 2. Potential gradient for typical neon glow-discharge tube

Transformers now used are of the shell type, with a magnetic shunt inserted between the primary and secondary coils, to give high leakage reactance. With this arrangement the required qualities of exceptionally good current regulation and poor voltage regulation are obtained. The secondary terminals may be short-circuited without increasing the secondary current to any appreciable extent beyond its normal value. With the balanced-type transformer, which has a grounded center tap on its secondary winding, either high-voltage lead may be grounded without increasing the current (0.028 ampere) above that resulting from a terminal-to-terminal short circuit. Incidentally, this current is only about 0.006 ampere higher than that which constitutes a maximum tube load.

Transformers for commercial neon sign lighting, also must meet rigid specifications in their insulating qualities, and must be able to withstand about four times their maximum secondary operating voltage. This is necessary because in the actual operation of high-voltage tubes, high-frequency transients with high peak voltages sometimes occur and provision for this must be made.

Aside from the transformer, for commercial use the high-voltage cables connecting the secondary terminals to the tube electrodes must pass voltage tests 50 per cent higher than those specified by the board of underwriters. Good insulation between the tube electrodes and the grounded metal housing must be provided also; for this purpose porcelain or glass bushings are used. Owing to metallic dust or moisture accumulation on these parts leakage or brush discharge sometimes occurs at the bushings; however, with the balanced-type transformer used, electrode punctures and strains on cables are reduced greatly, since the maximum voltage between any point and ground is only about half of its former value with the older transformers.

TUBE CHARACTERISTICS

The varying potential gradient of a typical neon glow-discharge tube is illustrated in Fig. 2 while Fig. 3 shows the general shape of the volt-ampere characteristic for a glow discharge. As may be noted, from *A* to *B* the curve has a negative slope. This is due to the fact that the cathode drop remains normal up to point *B* while the voltage of the positive column, having a negative characteristic, decreases with the current. At point *B* (zero slope) the cathode drop becomes abnormal and just balances the positive-column drop. From *B* to *C*, the abnormal cathode drop with an increase in current, increases more rapidly than the positive column decreases; this explains the positive slope.

In Fig. 4 may be seen a curve showing how the volts per ft. of positive column vary with tube diameter;

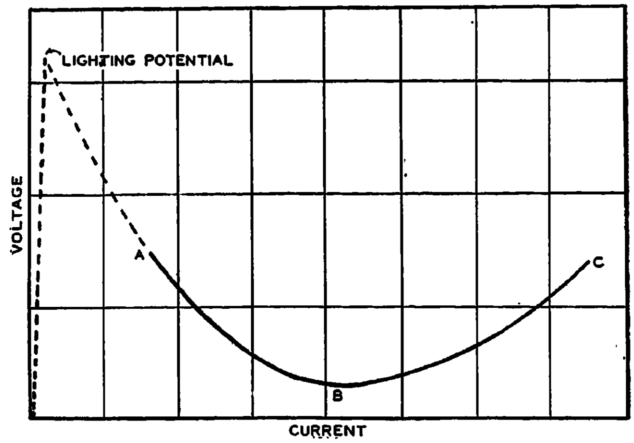


Fig. 3. Ideal volt-ampere characteristic for gaseous glow-discharg

No numerical values are given since these vary with other factors

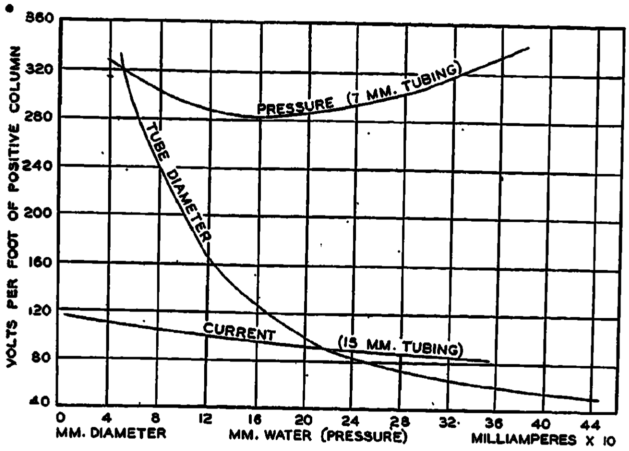


Fig. 4. Curves showing relation between volts per ft. of positive column and tube diameter; also typical curves for gas pressure and current

typical curves for current and gas pressure are given also. In general these will be found self-explanatory. Specifications for a typical neon sign installation are given in Table I. This will serve to summarize some of the points brought out by the discussion and curves.

TABLE I—SPECIFICATIONS FOR A TYPICAL NEON SIGN INSTALLATION

Tube	
Diameter	15 mm.
Length	60 ft. (4 tubes)
Gas	neon
Transformer	
Primary volts	110
Secondary volts (open)	15,000
Secondary volts (with load)	depends on tube length (max. 10,000)
Secondary milliamperes	25
Load watts	210
Volts per ft.	130
Watts per ft.	1.5
Lumens per ft.	36
Lumens per ft.-watt	24
Power factor	0.40 to 0.60
Life	10,000 to 15,000 hr.
Electrode drop per tube	250-300 volts

COLORS AND OTHER DEVELOPMENTS

As stated in the beginning practically all colors now are being made commercially by the use of the characteristic colors of the inert gases in clear glass tubing, and by the use of mercury and gas mixtures in colored glass tubing. It may be interesting to note here that a more efficient colored light can be produced from the characteristic glow of these various inert gases in clear glass tubing than can be obtained from incandescent lamps and filters. Significant also is the fact that the proper combination of colored tubes provides a true and efficient "daylight white" light source. Finally, an important feature of the light from gaseous conduction tubes is its uniformity of distribution and absence of glare.

Aside from sign lighting, high-voltage tubes are finding application as aviation indicators, beacons, showcase lights and for interior decorative effects. Ordinarily neon sign tubes have not lent themselves to moving effects as readily as have incandescent lamps. However, recent work in producing moving luminous phenomena in the tubes themselves such as moving "beads" and progressive lighting look promising.

The Propagation of Electric Waves

Progress made during the past year in the study of the propagation of electric waves is reported upon briefly by the A. I. E. E. electrophysics committee.

THE YEAR 1931 is the centennial of the discovery of electromagnetic induction by Faraday and by Henry; and also of the birth of Maxwell, the founder of the electromagnetic theory. It is appropriate, therefore, that a contribution of the A. I. E. E. electrophysics committee should deal with the propagation of electric waves.

Man now is employing and controlling electric waves of frequencies ranging from 0 to 10^{21} cycles per sec., but this discussion will portray the year's progress only in the lower portion of this range, for frequencies up to about 3,000,000,000 cycles per sec. Heat, light, and X-rays thus are disregarded.

ELECTROMAGNETIC WAVES ALONG CONDUCTORS

Propagation of electric waves along conductors is of interest to both the communication engineer and the power engineer. To the latter, one of the principal problems is that of the propagation of high-voltage waves, such as those induced by lightning.

Effects of change in circuit constants, effects of corona and other factors, and the changes in potential and in wave shape, all of which occur as such high-voltage

---

A progress report of the A. I. E. E. electrophysics committee. Not published in pamphlet form.

waves are propagated along power lines, have been studied by means of the portable cathode-ray oscillograph. Effects of change in circuit constants are discussed in a paper by McEachron, Hemstreet, and Seeyle (A. I. E. E. TRANS., Oct. 1930). In general, recent oscillographic tests on the propagation, reflection, and superposition of traveling waves have confirmed the purely theoretical predictions. Extensive oscillographic tests also were made to determine the effect of corona and other factors which decrease the potential and change the wave shape of high-voltage traveling waves. Oscillograms showing the effect of corona upon "artificial lightning" waves were especially important and interesting. These tests are described in a paper by Brune and Eaton at the Rochester A. I. E. E. District meeting April 29-May 2, 1931.

Cathode-ray oscillographic studies of the propagation of traveling waves in the armature windings of generators are described in papers by Boehne, and by Fielder and Beck (A. I. E. E. TRANS., Oct. 1930). The velocity of propagation in this case was found to be of the order of 10,000 mi. per sec. in the slots (Boehne).

Influence of the earth upon the propagation of electromagnetic waves along conductors has been subjected to much study during the year. Evans (*Phys. Rev.*, Vol. 36, p. 1,579, Nov. 15, 1930) has considered the case of a wire parallel to the surface of the earth with the earth itself as return, assuming a conductivity for the top stratum of the ground different from that of the remainder. Ollendorff (*Arch. f. Elekt.*, Vol. 23, p. 261, 1930) has dealt with this problem in considerable detail, being especially concerned with a top stratum of relatively high conductivity. Bowen and Gilkeson (JOURNAL A. I. E. E., Vol. 49, p. 657, Aug. 1930) have described some experimental results on the mutual impedances of ground-return circuits, checking the practical use of the theoretical formulas. Peterson (*Bell Sys. Tech. Jl.*, Vol. 9, p. 760, Oct. 1930) has discussed the transients in a similar case.

RADIO-WAVE PROPAGATION

While no important new discoveries in radio propagation seem to have been reported during the past year, there has been considerable progress in several lines of work which had been started during previous years.

Work with "ultra short" waves having lengths of less than 10 m. or frequencies greater than 3×10^7 cycles per sec., has become one of the major activities in wave propagation. Spurred on by the potential importance of these waves in communication, numerous workers have studied the phenomena qualitatively. Waves of lengths of less than 5 or 6 m. seem never to be reflected from the Kennelly-Heaviside layer. Therefore reception is not subject to fading, the name given to erratic fluctuations which are due to changing conditions in the ionized upper atmosphere and which are a source of considerable difficulty for waves longer than 10 m. However, phenomenally long ranges cannot be obtained. Transmission is best where an unobstructed optical path exists, but owing to the curvature of the earth such paths between points on the earth's surface are limited in length to the order of 100 or 200 mi. While an unobstructed path is best, these short waves will bend around obstacles, presumably by diffraction. As a result, the receiver may be located at points beyond the horizon of the transmitter, although there is a corresponding loss in transmission efficiency.

The extent to which reliance may be placed on diffraction obviously decreases with wavelength. For wavelengths in the order of 20 cm., it has been found, as expected, that an unobstructed path is essential; at any rate with the transmitting and receiving apparatus that has been available.

While an extended list of references cannot be given, the papers by Esau and Hahnemann (*I. R. E*, March, 1930) Jouast, (*L'Onde Electrique*, January, 1930) Ferrié (*Annales des Postes*, April, 1931) and "Micro Ray Wireless"—a new short-wave system demonstrated by I. T. and T. Laboratories, telephony on 18 cm. across the Strait of Dover, (*Electrician*, April 3, 1931) may be cited.

The role of the earth in radio propagation has claimed the attention of many investigators. Rolf (*I. R. E.*, March, 1930) has given curves which are based on Sommerfeld's well-known investigation and which makes this paper more useful to the engineer. Certain limitations in the applicability of these data have been pointed out by Wise (*I. R. E.*, November, 1930). The earth as a reflector of radio waves has been studied by Strutt (*Elek. Nach. Tech.*, February, 1930) Verman (*I. R. E.*, August, 1930) and others.

The Kennelly-Heaviside layer also has held the attention of many of the investigators. One of the more important results obtained has been the corroboration of the double-layer hypothesis advanced by Appleton. In this connection the work of De Mars, Gilliland, and Kendrick (*I. R. E.*, January, 1931) and of Goodall and Schafer (*U. R. S. I.*, May 1, 1931) may be noted. A minimum of effective ionization apparently exists between the heights of 110 km. and 250 km. In this work the echo method has been used to a considerable extent. Cases of relatively long delays due to slow group velocities under certain critical conditions have been observed and these may conceivably have a bearing on the very long delay echoes discovered by Hals and Stormer.

Hanson has presented orally some results on layer heights observed in the Antarctic by the Byrd expedition. It is of interest that even in the long winter night, reflections are obtained, although from greater heights than those found in other latitudes. In general, the phenomena were erratic.

The committee is indebted to K. B. McEachron, of its membership, and to J. C. Schelleng and J. M. Eglin of the Bell Telephone Laboratories, for material for this report.

Airplane Flight Aided by Electricity

By
C. F. GREEN
Non-member
General Electric Co.
Schenectady, N. Y.

Electrical instruments by giving accurate and reliable indications of direction, altitude, and of operating, traffic, and weather conditions, are contributing to safe flight even in dense fogs. Liberal use of instruments now available and development work along the line of new devices, are hastening the time when air transportation will compare favorably with other types.

AIR TRANSPORTATION in this country has witnessed remarkable growth. In a four-year period the ton mileage for mail and express transportation has been multiplied by 11 while passenger mileage over regular routes has been multiplied by 110. Other flying activities also have shown commensurate gains. Although regularity of service has increased, further progress is in order, for only when schedules can be maintained safely and on a basis comparable with other forms of transportation will the general public come to accept and depend upon air transportation. In this connection, however, it must be borne in mind that even the older forms of transportation are limited by many of the factors influencing air transportation. Railway trains still are delayed by fog and storm, and sea navigation with all its intensive development has not arrived yet at the point where an ocean liner can be brought into harbor in a dense fog and docked.

Up to the present time safety has been secured largely by the long experience and skill of the pilot. One of the greatest changes in the history of piloting however now is taking place as regards the pilot's attitude toward instruments and means of communication and traffic control. A pilot need no longer be without the aid either of instruments or ground personnel during flight.

In order that regularly scheduled flights may be established there are needed:

1. Means for keeping on the course (whether fixed or varied with weather or traffic conditions).
2. Means for checking operating conditions of engines and other equipment.
3. Means for communication enroute as well as at the terminals.
4. Aids for making a safe landing even in fog.

Means for Keeping on the Course

To stay on the course during the most severe weather conditions the pilot must find his way without sight of ground or beacon lights along the airway. Under such conditions he must rely solely upon instruments for direction since his senses then are inadequate and may be dangerously misleading.

For directional indication the pilot must depend upon compass indications. While a small magnetic or card compass fulfils minimum requirements, for accurate and reliable indication the magneto compass has been developed. This instrument is a remote-indicating device utilizing the horizontal component of the earth's field; it is an outgrowth of the earlier earth inductor compass. The generating unit in this instrument is mounted in some part of the plane which is relatively free from distorting magnetic influences, and is driven either by a wind rotor or by an electric motor supplied from the plane's battery. Two permalloy pole pieces are mounted so as to concentrate the earth's field through the armature. Normally the two pole pieces are held in an East-West direction by a course-setting mechanism located within easy reach of the pilot; when in this position no magnetic field is impressed upon the rotating armature. Any change in the direction of flight which will shift the pole pieces from an East-West position brings the permalloy bars under the influence of the horizontal component of the earth's field. Thus a current is generated which shows by means of a conveniently located indicator, deviation to right or left from the determined course. The pole pieces are maintained in a horizontal position by means of a pendulum which is either liquid or air-damped.

All magnetic compasses are subject to errors when accelerations occur which permit the vertical component of the earth's field to influence the sensitive element. To overcome this the turn compensator has been developed. This device employs an electric gyro element, by means of which a potential is impressed upon the magneto compass circuit which bucks the compass potential caused by the acceleration or turn.

In addition to its use as turn compensator, the gyro element may be used independently as turn indicator to aid in maintaining a straight flight. A separate indicator is provided for this use being connected in the same circuit as the turn compensator. A turn indicator obviously is one of the most important instruments

---

From "Electrical Solutions of Problems of Regular Scheduled Flight," (No. 31-M3) to be presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, Calif., Aug 25-28, 1931.

used in blind flying and accordingly much development work has been done to make it reliable.

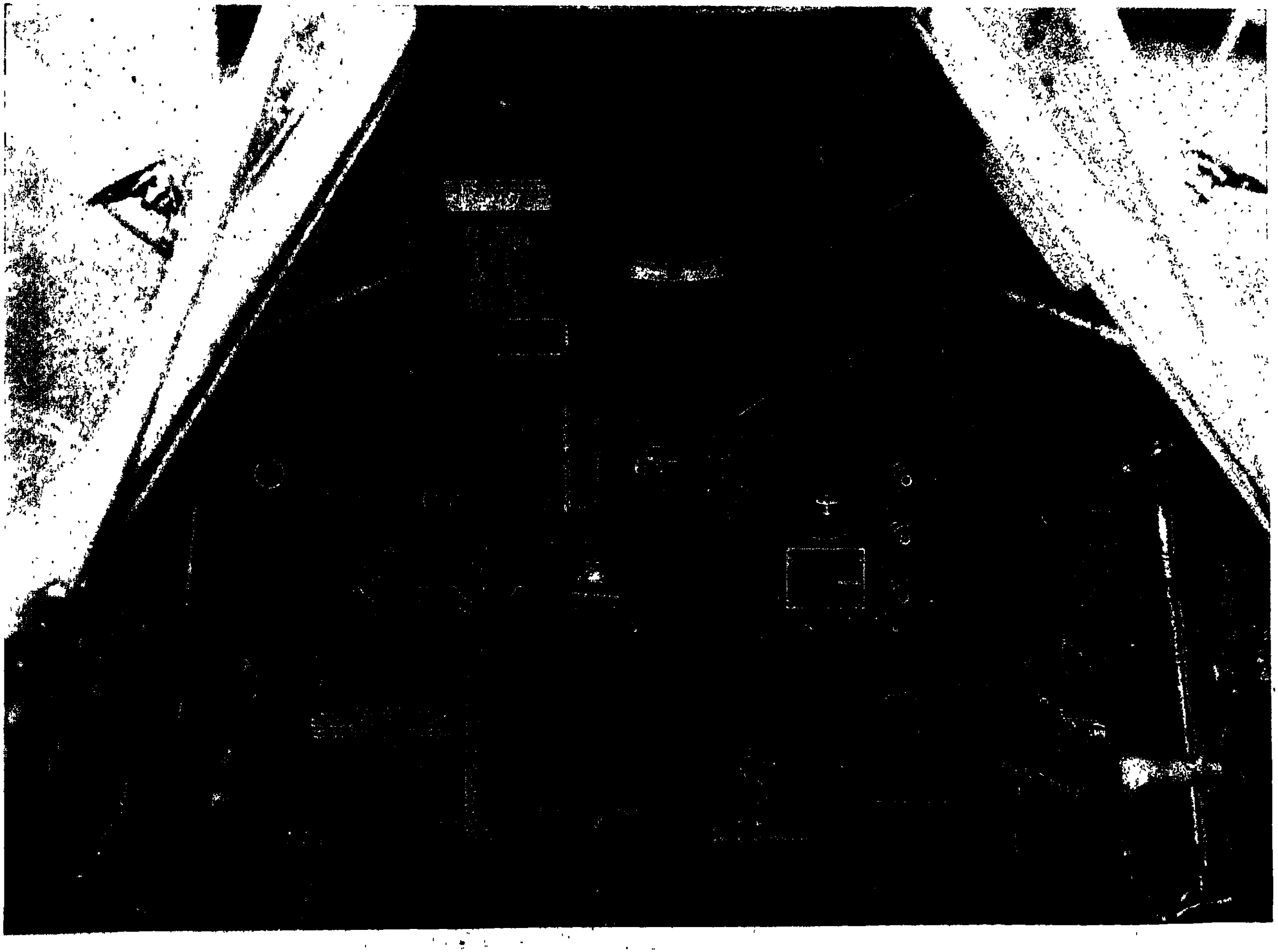
AUTOMATIC CONTROL

Various forms of automatic control have been experimented with for many years, and development is proceeding in all countries to free the pilot from strain and permit him to devote his attention to "avigational" and other matters. One such arrangement has been developed utilizing the magneto compass as the direction-sensitive element and turn compensator as the turn-sensitive element. With this arrangement the magneto compass lays down a definite base line and the turn compensator maintains correct indications during accelerations and turns. A sensitive polarized relay replaces or is used in combination with the compass indicator and through a vacuum-tube circuit, controls two magnetic clutches of an electric steering mechanism. A follow-up system provides for deflection of the rudder from a chosen neutral position proportional to the departure of the craft from the course. The accuracy with which a course may be followed with the aid of this arrangement is remarkably good.

RADIO BEACONS

To be able to fly a straight course blindly is of little advantage, however, unless the aircraft reaches its destination, and no matter how accurate the instruments aboard the plane may be they do not indicate drifting due to winds. Radio has been found useful in this connection in that it furnishes the aviator with reference points or axes. Two general classes of equipment in use are (1) course beacons and (2) direction finding apparatus. In this country the first class is employed almost exclusively along the airways, the two types in general use being respectively aural and visual beacons. The aural type transmits a code signal alternately from two loops thus providing for four courses at each beacon. The listening pilot hears a *dash-dot* or a *dot-dash* signal when off course, depending upon his direction from the course, and a series of long dashes separated by the station's identifying signals when on course.

With the visual type of beacon, the interlocking signal system is replaced by one employing two modulation frequencies which are received with equal intensity when on course and with unequal intensity



Interior view of a typical airplane cockpit showing the multiplicity of instruments to assist the pilot in maintaining safe flight when off the course. While visual indicators employing tuned reeds sometimes are used, pointer-type indicators possessing certain advantages over the reed indicators have been developed.

For flying off the established airways a homing device adaptor has been developed for standard aircraft receivers. This is used with a fixed wing loop and indicates by a meter on the instrument panel whether the plane is on or off course directly toward the station tuned in. Since this device uses the ordinary broadcast wave band as well as that of the beacons, the plane may be directed at any broadcasting station within range; tests have shown that in general a pilot can fly toward a powerful broadcasting station from a distance of about 200 mi.

ALTIMETERS

Among other indications the pilot is vitally concerned in knowing his height above the terrain over which he is flying. Elevation above the starting point is given by a barometric altimeter which is included in the normal equipment of any plane, but inadequate over rough country. The radio altimeter is one of the three general types of instruments which have been developed to solve this difficulty. Operation of this device is based upon the principle that if a radio wave is radiated from an antenna and reflected back to the source by a large, conducting mass, the change in the antenna characteristics will result from the combined outgoing and reflected waves. While this device does not give positive indications at elevations of less than 350 ft., indications of high accuracy may be obtained at altitudes of 650 ft. or more.

MEANS OF CHECKING OPERATING CONDITIONS

Flight and avigation instruments must be supplemented by other instruments showing engine and atmospheric conditions, and general operation of the plane. Here is a wide field for remote electrical indication as multi-motor planes find increased application to transport service. Some of the instruments of this type which have been developed include engine tachometers, oil- and fuel-pressure gages, oil- and water-temperature indicators, and cylinder-temperature indicators. Although recently many different types of these electrical instruments have received publicity, they consist principally of instruments already standardized for other uses, but adapted to meet the special needs of the airplane. The remote indicating features of these instruments make their installation extremely simple as compared with present equipment with its long lengths of tubing and flexible shafting.

MEANS OF COMMUNICATION

A radio beacon may serve to keep a pilot on his course but it does not inform him of conditions along the airway. For this purpose, radio telephone rather than telegraph has been chosen by the majority of transport operators. Now, the pilot under this guidance is in an entirely different situation than a few years ago. Instead of flying into unknown and shifting weather conditions single-handed and without accurate information, he has available many contacts through his own radio equipment. In addition, traffic control at all times during flight has made possible an increase in the safety of landing under conditions of low ceiling and poor visibility.

AIDS FOR LANDING

Safe landing on a fog-bound terminal remains the great problem confronting air transportation. In general, transport companies avoid any possibility of being forced to land in a fog in the same way that all ocean liners meet their corresponding problem. However, organizations now are making strenuous efforts to make safe the blind landing of a plane, and here it is that radio, light, sound, and all other agencies are needed, for each may contribute to the solution. It is through a coordinated system that ultimate success may be hoped for.

Blind landing requires the guidance of the plane from the beacon course, or course determined by direction finding, to an approach course at the airport. In addition, the runway position must be determined; the pilot also must know his height above ground and traffic conditions about the port. Radio plays an important part in directing the plane to the field, in indicating the field boundaries and in providing the pilot with means of communicating with the ground personnel.

Light also furnishes some aid for night flying under conditions of low visibility; however, due to scattering of the light by the fog particles ordinary boundary lighting and floodlighting are of little avail for fog landings. Consequently lighting cannot be considered of much aid under such conditions unless modulated light or intense flashes are available.

SONIC ALTIMETER

For height-above-ground indications in landing, the sonic altimeter is especially adapted. As in depth sounding, sound waves reflected from the ground are utilized. From a compressed-air whistle mounted in a megaphone which directs the signals downward from the aircraft short blasts are blown automatically at brief intervals. The echo of the outgoing signal is received in a second megaphone which is connected through a high-pass acoustical filter to a stethoscope worn by the pilot. A timing device mounted on the instrument panel indicates altitude, this indicator being calibrated directly in feet. As the distance above ground decreases, the interval between the two signals naturally decreases also; experience has shown that when the outgoing signal and echo appear to blend, the plane is at an altitude of about 5 ft. or less.

So varied are conditions under which air transport is carried out that no single arrangement can be said to be best. A system which will fit most satisfactorily into local conditions should be adopted. Whatever method is ultimately used, however, must fulfil the requirements of simplicity, lightness, and reliability.

In conclusion it is quite safe to say that, through the use of sensitive and accurate instruments, safe and regular flights can be established in so far as avigational problems are concerned. Further development work along this line together with the added experience of operators, are hastening the time at which this service will assume a position comparable to other forms of transportation.

Desirable Accuracies in Instrument Transformers

Errors in both the producer's total meter registrations and the consumer's single meterr gistration are analyzed and evaluated by the "probable error" method. Accuracies better than 0.5 per cent are shown to be valueless from a practical standpoint.

By
E. C. WENTZ
Associate A. I. E. E.

Westinghouse Elec. & Mfg. Co., Sharon, Pa.

HOW MUCH SHOULD BE PAID for increased accuracy in instrument transformers? Are power companies seeking accuracies out of proportion to the returns therefrom? Upon these and other important questions related to instrument transformer accuracy the author has attempted to shed some light. As a result of his detailed analysis he has concluded that with normal metering burdens, accuracies better than 0.5 per cent are valueless commercially. It is shown also that accuracies better than 0.5 per cent seldom can be guaranteed, and thus are of no practical value except as they may indicate that the apparatus may be overloaded safely, or that the guarantee has a larger factor of safety.

It is well known that errors in either current or voltage transformers may be decreased by increasing the cross-section of either the copper or the iron. This, however, will inevitably increase the cost of the transformer. The problem then becomes one of analyzing the errors present in the conventional type of instrument transformer and evaluating these from an economic standpoint.

If the transformers in question are used in conjunction with a watthour meter, the aggregate error in meter registration will be due to errors in (1) the voltage transformer, (2) the current transformer, and (3) the watthour meter.

The error introduced by the voltage transformer is usually a constant quantity which can be obtained either by measurement or from a calibration curve. This remains constant so long as the burden and line voltage are constant.

Errors introduced by the current transformer may be shown to vary with the line current (see Fig. 1). This variation may be measured, or obtained from a calibration curve. However, meter registration errors due to the current transformer depend also upon the load cycle and load power factor, as may be noted from Fig. 1. The net effect is that in general the combined errors will be such as to make any meter to which the transformer may be connected, run fast at full current and slow at light currents, although this condition is sometimes reversed at very low-line power factor.

Similar variation exists in the errors introduced by the watthour meter; and the same difficulty will be encountered in estimating the error in total meter registration. A curve showing typical watthour-meter error is given in Fig. 2.

To determine the magnitude of error in total meter registration in terms of the errors in the current transformer and watthour meter is not strictly possible without a vast amount of work involving among other things a record of the load cycle. A relation may be approximated, however, by the introduction of what will be called the "probable error." The idea of a "probable error" is familiar to most engineers, but as used in this particular problem may be defined in the following manner: Each current transformer and each meter introduces an uncertain error into the total watthour-meter registration. This error is uncertain because of its dependence upon the load cycle and other variable factors; its most probable magnitude, however, is designated as the "probable error" and may either add or subtract from the true readings.

An exact determination, or even an estimation of the probable error due to the current transformer, is impossible. However, the probable error will not be greater than the maximum ratio error over the range from 10 to 100 per cent current. This assumption is of course empirical; it is based on the fact that with most current transformers and usual load power

---

Written especially for ELECTRICAL ENGINEERING. Not published in pamphlet form.

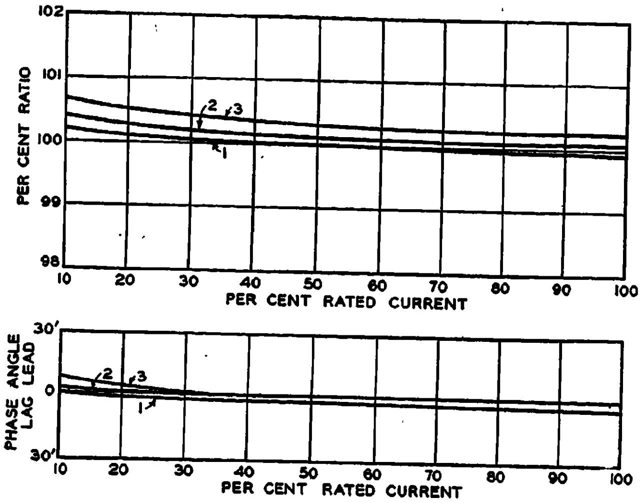


Fig. 1. Ratio and phase-angle curves for typical current transformer

1. 2.5 voltamperes, 0.90 power factor
2. 15 voltamperes, 0.90 power factor
3. 50 voltamperes, 0.50 power factor

factors the maximum error in wattmeter indication does not differ greatly from the maximum transformer-ratio error.

It is conservative to assume the maximum error to be the probable error in registration. Accordingly, this assumption will lead to a pessimistic conclusion, the actual errors being less than predicted by this analysis. This point should be kept in mind following through the rest of the argument.

Probable Error for Producer

A typical three-phase metering installation will involve two current transformers, two voltage transformers, and a watthour meter containing two elements. As already pointed out, the voltage-transformer error usually is constant and may be eliminated.

If the current transformer introduces a probable error of P_1 per cent, and one watthour-meter element an error of P_2 per cent, the total probable error of the combination is $\sqrt{P_1^2 + P_2^2}$ as these errors multiply or divide (see any college physics laboratory manual for combination of probable errors). The error of the combination in the other phase also is $\sqrt{P_1^2 + P_2^2}$. The most probable correct power reading will be the registration of the meter, and the probable aggregate error in this registration will be

$$\sqrt{\frac{P_1^2 + P_2^2}{2}}$$

as the errors in the two phases add or subtract.

In a large power system there will be n such installations, each introducing the same probable error. Therefore the total probable error for the entire system will be

$$\sqrt{\frac{P_1^2 + P_2^2}{2n}}.$$

These expressions indicate the following:

1. It is of little use to reduce one of the errors P_1 or P_2 unless the other is reduced correspondingly. The magnitude of P_1 and P_2 logically should be the same.

2. If n is large enough, the probable error in the individual installation may be objectionably large without causing the probable error in the grand total of all the registrations to be worthy of consideration.

The accuracy of the total registration, which it should be remembered represents the total income of the producer, is insured then by the mere number of meters in a large system, whether or not exceptionally accurate metering apparatus is installed.

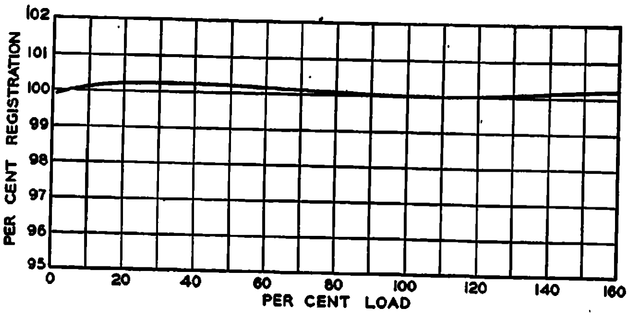


Fig. 2. Load-registration curve for a typical watthour meter

Probable Error for Consumer

To extend the idea of probable error to find the error in the total expenses of a given consumer, it must first be considered that one meter registration generally represents only a small part of any consumer's total expenses. If each of n commodities making up the major part of a consumer's purchased supplies are measured with a probable error of P_1 per cent, the resultant probable error in his total commodity bill will be

$$\sqrt{\frac{P_1}{n}}$$

(assuming the various items to be equal in amount). If one of these individual errors P_1 could be reduced to zero, the probable aggregate error in the bills for the remaining $n - 1$ items would be

$$\sqrt{\frac{P_1}{n-1}},$$

and in per cent of the total bill would be

$$\sqrt{\frac{P_1}{n-1}}\left(\frac{n-1}{n}\right).$$

Reducing one probable error to zero then would reduce the total resultant error from

$$\sqrt{\frac{P_1}{n}} \text{ to } \sqrt{\frac{P_1}{n}}\sqrt{\frac{n-1}{n}}.$$

To reduce the probable error in the measurement of one commodity only, is obviously of negligible benefit. It is evident also that the probable errors in the measurement of the various commodities logically should be the same.

Commodities purchased by weight are weighed on a scale with a probable error of perhaps 0.5 per cent, as the scales ordinarily are used; commodities purchased by volume are measured or metered to within perhaps 0.5 per cent also. It would seem, then, that unless electric power is by far the largest commodity purchased, it will be impractical to meter it to an accuracy better than that attained in the measurement of other commodities supplied.

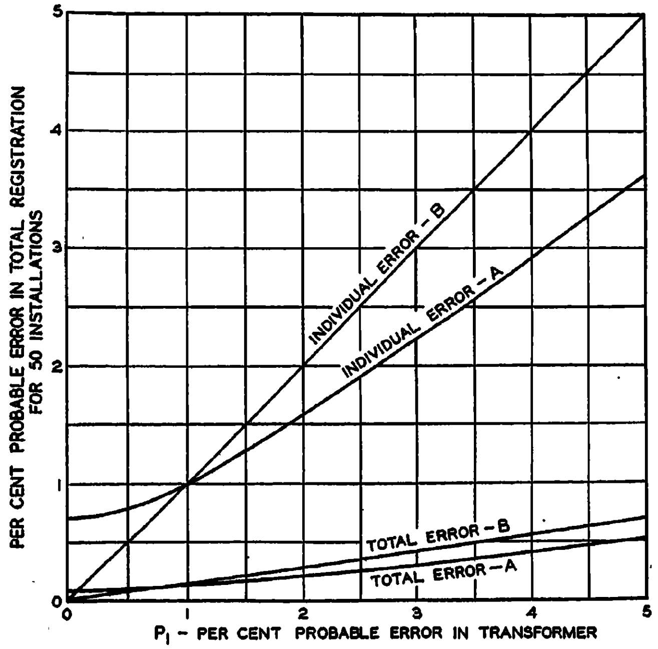


Fig. 3. Probable error in registration for different current-transformer and watthour-meter errors

P_1 = probable error in current transformer

P_2 = probable error in watthour meter element

A. P_2 constant at 1 per cent

B. $P_2 = P_1$

To return to the expressions for probable error in meter registration, and to consider numerical examples:

$$\text{Individual probable error} = \sqrt{\frac{P_1^2 + P_2^2}{2}}$$

$$\text{Total probable error} = \sqrt{\frac{P_1^2 + P_2^2}{2n}}$$

If $P_1 = P_2 = 1$ per cent

and $n = 20$, (a small number).

the probable errors are

$$\sqrt{\frac{P_1^2 + P_2^2}{2}} = 1 \text{ per cent for the individual}$$

$$\sqrt{\frac{P_1^2 + P_2^2}{2n}} = 0.22 \text{ per cent for the total.}$$

If $P_1 = P_2 = 0.5$ per cent and $n = 50$ (a more usual case) the probable error will be 0.5 per cent for the individual but only 0.07 per cent for the total. This aggregate error of 0.07 per cent is within the limits of precision accuracy; still 0.5 per cent represents a reasonable accuracy which may be expected in most cases.

From the foregoing it may be seen that the resultant probable error decreases in the same proportion as do the errors P_1 and P_2. If the probable individual error and the probable total error in meter registration are plotted against P_1, assuming P_2 to remain constant at 1 per cent, curves *A*, Fig. 3 are obtained. If $P_1 = P_2$, curves *B* result as P_1 and P_2 vary together. The curves *A* show that if $P_2 = 1$ per cent, it does little good to reduce P_1 below 1 per cent, since reducing it to zero reduces the total error to only 0.71 per cent.

As a final conclusion it appears a well established fact that no certain advantage is to be expected from more accurate metering apparatus than now is available. That accuracy better than 0.5 per cent in a meter or current transformer is of no commercial advantage has been amply demonstrated. Furthermore, this conclusion is supported by the fact that current transformer errors cannot be measured with present commercial testing apparatus with much better accuracy than 0.1 per cent in ratio and 5 min. in phase angle. Consequently, attempts to meet accuracies of better than 0.5 per cent generally result in arguments which never are settled satisfactorily.

Konel—

A Substitute for Platinum

A MAN set out to find a cheap substitute for platinum. He was so successful that for almost a year his results were not taken seriously.

Oxide-coated filament for radio tubes was known as early as 1904; platinum as a core appeared to be the best material for life, strength, and emission of electrons.

From *Research Narratives*, May 15, 1931, published by the Engineering Foundation, 29 W. 39th Street, New York, N. Y. Based on information supplied by Erwin Foster Lowry, Ph. D., research physicist, Westinghouse research laboratory, East Pittsburgh, Pennsylvania.

In 1925, five years after radio broadcasting had aroused public imagination, tubes were being made in ever-increasing quantities with platinum or platinum-iridium core filament. Platinum people were overjoyed, but not makers of tubes. Material for filaments was costing $186 an ounce.

Dr. E. F. Lowry, research physicist of the Westinghouse research laboratory, undertook a search for a cheaper substitute. Iron, nickel, nichrome, tungsten, various ferrous alloys already were pronounced worthless. All had a poisonous effect on emission or had proved mechanically weak. But nickel looked good to Lowry in spite of its reputed mechanical frailty.

The first filament of pure nickel gave surprising results. Emission appeared to be as good as with platinum cores; no more trouble arose from mechanical failures. Scientists, tube manufacturers, even colleagues, hesitated to believe that the first attempt had succeeded when hitherto undisputed authority had pronounced nickel no better than other metals. Against claims that nickel filaments should have a life of only 80 hr., Lowry produced tubes on life tests for 1,500 hr. and still burning. But none of his nickel filaments were manufactured commercially.

Convinced that he was working in the right direction he tried 20 per cent cobalt; the crystalline structure was unsatisfactory and could not be drawn. The case looked hopeless when he thought of the qualities of cobalt-ferrotitanium (a compound of iron and titanium) wire used in experiments several years previously. The first filament of nickel, cobalt, and ferrotitanium, in proportion of 80, 20, and 10, gave results better than ever before. Hundreds of experiments have since been made, but the alloy used today is essentially the same as that produced by Lowry's first attempt.

He named the new metal "konel," and in December 1926 persuaded the Westinghouse Lamp Company to make 50 commercial tubes with it as filament core. About the same time, the manufacturers discovered that Lowry was right also about nickel and started to use that for filaments. Within a year every manufacturer ceased the use of platinum in radio tubes, and none has used it since. Platinum-iridium cost $1,600 per lb.; konel costs a few dollars.

Use of konel not only appreciably increased tube life (operating 175 deg. colder than platinum filament), but also showed definitely that the filament core had a marked influence on emission. A new theory of electron emission from oxide filaments has been formulated; on this work the discoverer is now engaged.

Konel is harder to forge than high-speed steel and is very tough at high temperatures, when most metals lose their strength. It is extremely resistant to most acids, does not sputter, does not scale like iron under heat, and has a high electrical resistance. These unusual characteristics give promise of many uses outside radio tubes. It is an electric furnace product of extreme purity.

Mutual Impedance of Grounded Wires

A formula is given for the mutual impedance between two insulated wires of negligible diameter lying on the surface of the earth and grounded at their end-points.

By
R. M. FOSTER
Member A. I. E. E.

American Tel. & Tel. Co., New York

WE ASSUME the earth to be flat, semi-infinite in extent, of unit permeability, of negligible dielectric constant, and of uniform conductivity λ, using c. g. s. electromagnetic units. The air is also assumed to be of unit permeability and of negligible dielectric constant. All displacement currents are thus neglected both in the earth and in the air. This is the assumption which is ordinarily made as a first approximation at power frequencies for the shorter transmission lines.

The mutual impedance between circuits consisting of insulated wires of negligible diameter lying on the surface of the earth and grounded at their end-points is then found to be

$$Z_{12} = \frac{1}{2\pi\lambda}\int\int\left\{\frac{d^2}{d\,S\,d\,s}\left(\frac{1}{r}\right) + \frac{\cos\epsilon}{r^3}\left[1-(1+\gamma r)\,e^{-\gamma r}\right]\right\}d\,S\,d\,s \quad (1)$$

The integrations are extended over the two wires S and s, their elements $d\,S$ and $d\,s$ being separated by the distance r and making the angle ϵ with each other. In this formula $\gamma = (i\,4\,\pi\,\lambda\,\omega)^{1/2}$ is the propagation constant in the earth for plane waves which vary with the time as $e^{i\omega t}$, where $\omega = 2\,\pi$ times the frequency and $i = (-1)^{1/2}$.

This mutual impedance formula (1) may be written in the equivalent form

$$Z_{12} = \int\int\left[\frac{1}{2\pi\lambda}\cdot\frac{d^2}{d\,S\,d\,s}\left(\frac{1}{r}\right) + i\omega\frac{\cos\epsilon}{r}\left\{\frac{2}{(\gamma r)^2}\left[1-(1+\gamma r)e^{-\gamma r}\right]\right\}\right]d\,S\,d\,s \quad (2)$$

The complex factor

$$\frac{2}{(\gamma r)^2}\left[1-(1+\gamma r)\,e^{-\gamma r}\right] \quad (3)$$

From "Mutual Impedance of Grounded Wires Lying on the Surface of the Earth," *Bell System Technical Journal*, July 1931.

approaches unity as ω approaches zero, and Z_{12} then agrees with the d-c. mutual impedance as given by G. A. Campbell.[1] Introducing this factor (which is a function of γr only) into the reactance term for the d-c. mutual impedance between two elements dS and ds gives the general expression for their mutual impedance corresponding to the propagation constant γ. The variation of the complex factor (3) for increasing values of γr is shown very clearly in the figure, where the real and imaginary parts of (3) are plotted for increasing values of $r' = |\gamma r| = (4\pi\lambda\omega)^{1/2} r$. The real part, it may be noted decreases rapidly from the initial value unity as r' increases, while the imaginary part is always negative, decreasing from zero to a minimum value (approximately -0.3 for $r' \doteq 1.5$) and then increasing towards zero, although it does not approach zero so rapidly as does the real part.

The first three terms in the expansion of Z_{12} for low frequencies are given by

$$Z_{12} = \frac{1}{2\pi\lambda}\left(\frac{1}{Aa} - \frac{1}{Ab} - \frac{1}{Ba} + \frac{1}{Bb}\right) + i\omega N_{Ss} + (1-i)\frac{1}{3}(8\pi\lambda\omega^3)^{1/2} A\,B\,a\,b\cos\theta + \dots, \qquad (4)$$

where N_{Ss} is the mutual Neumann integral between the two wires S and s of arbitrary form but with end-points A, B and a, b respectively; θ is the angle between the straight lines $A\,B$ and $a\,b$. The first two terms in this expansion are precisely the d-c. mutual impedance as given by G. A. Campbell.

The first term in the expansion of Z_{12} for a long straight wire S and any wire s located near the midpoint of S is

$$\int\left[\frac{1}{\pi\lambda x^2} - \frac{\gamma}{\pi\lambda x}K_1(\gamma x\cdot\right]\cos\epsilon\,ds, \qquad (5)$$

x being the positive distance from ds to S, and ϵ the angle between ds and S.

$$K_1(z) = -\frac{1}{2}\pi H_1^{(1)}(iz)$$

is the Bessel function of the second kind for imaginary argument as defined by G. N. Watson.[2]

The expression in square brackets in (5) is the mutual-impedance gradient, parallel to an infinite wire at a positive distance x from the wire. It agrees with the results published independently by F. Pollaczek,[3] J. R. Carson,[4] and G. Haberland,[5] and has been employed to obtain numerical results since 1917. Pollaczek has also investigated the case of two grounded circuits of finite length.[6]

The mutual impedance dZ_{12} between a short, grounded circuit dS and a counterclockwise small loop of area da, on the surface of the earth, may be found by applying Stoke's theorem to formula (1), obtaining

$$dZ_{12} = \frac{dS\,da}{2\pi\lambda}\cdot\frac{\sin\phi}{r^4}\left[3 - (3 + 3\gamma r + \gamma^2 r^2)e^{-\gamma r}\right], \qquad (6)$$

where ϕ is the angle which dS makes with r, the line from da to dS.

By a further application of Stoke's theorem we may obtain the mutual impedance between two counterclockwise small loops dA and da; namely,

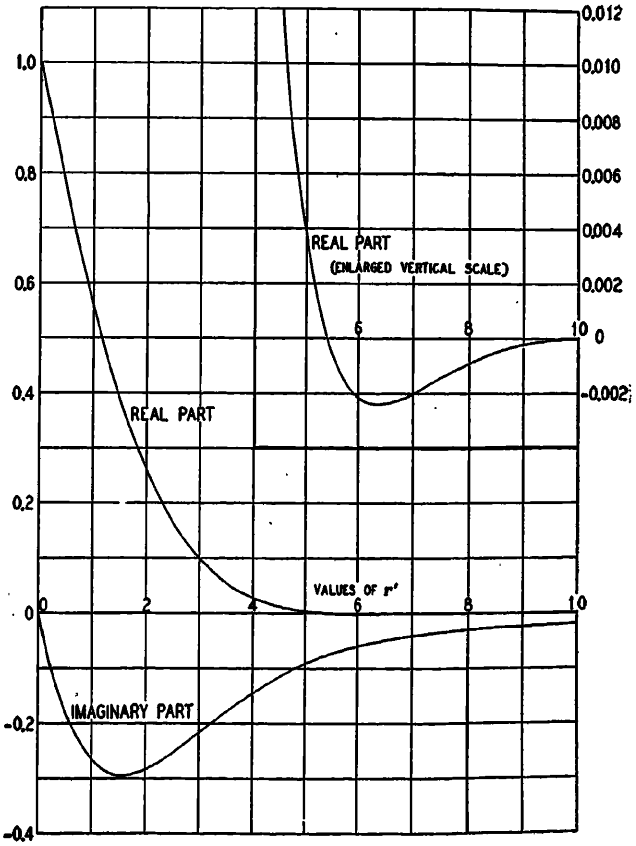
$$dZ_{12} = \frac{dA\,da}{2\pi\lambda}\cdot\frac{1}{r^5}\left[(9 + 9\gamma r + 4\gamma^2 r^2 + \gamma^3 r^3)e^{-\gamma r} - 9\right]. \qquad (7)$$

BIBLIOGRAPHY

1. MUTUAL IMPEDANCES OF GROUNDED CIRCUITS, by G. A. Campbell, *Bell System Technical Journal*, 2, October 1923, pp. 1-30.

2, THEORY OF BESSEL FUNCTIONS, by G. N. Watson, Cambridge, 1922, pp. 77-78.

3. UBER DAS FELD EINER UNENDLICH LANGEN WECHSELSTROMDURCHFLOSSENEN EINFACHLEITUNG, *Elektrische Nachrichten-technik*, 3, September 1926, pp. 339-359.



Real and imaginary parts of the complex factor,

$$\frac{2}{(\gamma r)^2}\left[1 - (1 + \gamma r)e^{-\gamma r}\right],$$

plotted as functions of $r' = |\gamma r| = (4\pi\lambda\omega)^{1/2} r$

---

1. For numbered references see bibliography.

4. Wave Propagation in Overhead Wires with Ground Return, by J. R. Carson, *Bell System Technical Journal*, *5*, October 1926, pp. 539-554.

5. Theorie der Leitung von Wechselstrom durch die Erde, by G. Haberland, *Zeitschrift fur angewandte Mathematik und Mechanik*, *6*, October 1926, pp. 366-379.

6. Gegenseitige Induktion zwischen Wechselstromfreileitungen von endlicher Lange, by F. Pollaczek, *Annalen der Physik*, (4), *87*, December 1928, pp. 965-999. His assumptions regarding conditions at the ground connections seem to depart considerably from the conditions assumed in the present paper, and moreover his results are not expressed in convenient form for direct comparison with the formula given above for Z_{12}.

Burn-Off Tests in Low-Voltage Networks

By
GEORGE SUTHERLAND and D. S. MacCORKLE
Fellow A. I. E. E. Associate A. I. E. E.
New York & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.

An extensive series of tests on standard and experimental cables installed in accordance with standard accepted practise for a-c. low-voltage underground networks, are outlined in this article. Results obtained are useful not only in determining mains-conductor size and network-transformer spacing, but also for indicating desirable future developments in cables for this service.

Fault in single-conductor buried cables cleared in 40 sec. at initial location; total current—5,800 amperes

IT IS RECOGNIZED generally that one of the most essential requirements to be met in the operation of a-c. low-voltage networks is the ability of the system to burn faults clear in the underground cables automatically. The purpose of the present study was to determine the characteristics of fault clearance in such networks, tests having been made on both standard and experimental cables.

Faults in cables may be classified with respect to their ability to dissipate the heat generated as, (1) a fault having a thermal capacity less than that of the cable conductors, and (2) a fault having a thermal capacity greater than that of the cable conductors. The clearance of a fault of the first class depends therefore upon the destruction of the fault itself or a progression of the fault and the subsequent burning clear of the cable conductors at a location remote from that of the initial fault; the clearance of a fault of the second class depends upon the fusing of the cable conductors joining the fault.

Nearly all operating experience in low-voltage a-c. network systems has been with rubber- or paper-insulated lead-covered cables. Both operating and previous test data have shown that all ground faults between the conductor and lead sheath have cleared. Tests made (*Low-Voltage A-C. Networks of the Standard Gas and Electric Company's Properties*, by R. M. Stanley and C. T. Sinclair, A. I. E. E. Trans., Vol. 49, p. 278) have indicated also that a minimum of 5,000 amperes is required to clear faults in 500,000-cir. mil cables and a minimum of 3,500 amperes to clear faults in 250,000-cir. mil cables.

Equipment and Tests

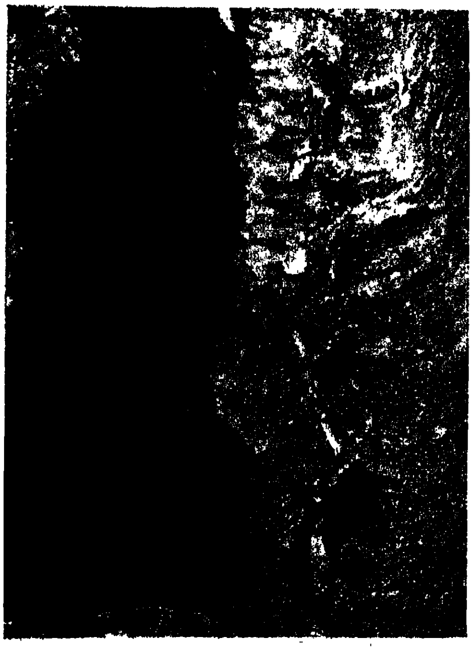
The test set-up consisted of 4,000/230-volt network transformers, current-limiting devices, and instruments for voltage and current indications. The transformers were supplied with 60-cycle power from an isolated substation bus section, and were connected so that a 900-kva. capacity supplied power to each side of the fault in the test cable connected in the low-voltage circuit. Both experimental and standard cables were installed

---

From "Burn-Off Characteristics of A-C. Low-Voltage Network Cables," (**No. 31-66**) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931.

for test under conditions simulating present underground-network constructions. A total of 86 burn-off tests was made. Two types of multiple-conductor buried non-magnetic sheath cables were tested, each cable containing three No. 4/0 phase conductors, one No. 2/0 neutral conductor, and one No. 6 conductor which would be required in an actual system layout for multiple street lights. Tests were made also on eight types of single-conductor No. 4/0 buried non-magnetic-sheath cables; four types of No. 4/0 non-metallic-sheath cables for duct installation; and one each of No. 4/0 rubber-insulated, 350,000-cir. mil and 500,000-cir. mil paper-insulated lead-covered cables. In addition to these, two tests were made on No. 4/0 bare conductors, spaced and buried in relatively dry soil.

In general, the tests included a wide variety of faults, the insulation and coverings of the cable in most cases being stripped for a length of approximately six inches from the conductors to be short-circuited; the conductors were then forced together for a length of about three inches and bound in that position with friction tape. In some of the tests on multiple-conductor buried cables a large iron clamp was used to force the conductors together. Several investigations were made also on copper-to-copper and copper-to-ground faults of the point-contact class.



Remains of single-conductor non-magnetic-sheath cables and ducts after test

(Left) total current—0 to 5,000 amperes for 11.5 min.; (right) total current — 0 to 3,600 amperes for 21.5 min.

CONCLUSIONS

Results of these tests, together with other information obtained from operating data and previous publications, are summarized in the following general conclusions:

1. Point-contact and conductor-to-sheath faults.

Faults of this type occurring in single-conductor lead-covered cables in 120/208-volt networks usually were cleared within a period of several seconds irrespective of conductor size where the minimum current available was approximately 3,000 amperes.

2. Copper-to-copper faults.

These faults, made as described by taping the bared conductors together for a length of about three inches, will clear at the fault location within one minute's time (usually less) provided certain minimum values of short-circuit current (see accompanying table) are maintained during the entire short-circuit period.

MINIMUM SHORT-CIRCUIT CURRENT FOR CLEARING COPPER-TO-COPPER FAULTS IN SINGLE-CONDUCTOR CABLES

	Short-circuit current in amperes	
Conductor size	Per conductor	Total
No. 4/0	3,000	6,000
350,000 cir. mils	4,000	8,000
500,000 cir. mils	5,000	10,000

3. Faults in buried cables.

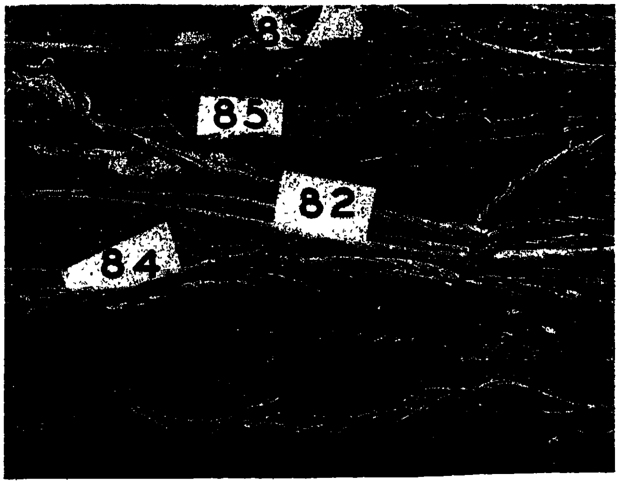
Buried single-conductor non-magnetic-sheath cables when dropped into the trench at random possess approximately the same general burn-off characteristics as do single-conductor cables installed in four-inch non-metallic ducts. These characteristics are improved somewhat by separating the cables.

4. Faults in buried multiple-conductor cables.

Burn-off characteristics of this type of cable with non-magnetic sheath makes it undesirable for low-voltage a-c. network distribution. The better burn-off characteristics of buried single-conductor cables are attributed largely to a wider separation of the conductors, and coverings impregnated with a flameproof compound.

5. Oiled paper *vs.* rubber insulation for buried cables.

In the matter of burn-off characteristics vulcanized sulfinated oiled-paper insulation appears to offer no improvement over ordinary rubber insula-



500,000-cir. mil paper-insulated lead-covered cables removed from ducts after test

Note cables of test No. 83 in which a total current of 10,400 amperes cleared 3-in. contact fault in 1.25 min. Initial current for the remaining cables was from 7,300 to 9,000 amperes tions. Analyses show no appreciable difference in the explosibility and inflammability of gases produced with either type of insulation on lead-covered cables.

6. Time required for fusing.

Assuming current values to be constant calculated values of fusing time are sufficiently accurate for all practical purposes provided total arcing time does not exceed approximately eight minutes.

7. Gases liberated during fault period.

With either oiled-paper or rubber insulation, explosions may occur due to gases liberated by arcing faults in underground cables if these faults persist for more than five minutes.

Analyses of these gases indicate that approximately 50 per cent of the gaseous mixture is combustible; and laboratory tests show that the gases from both types of insulation contain in general the same constituents and are evolved in the same relative quantities. Gases emanating from the burning of fiber duct now used in underground systems do not appear to affect the combustibility of the gaseous mixture from an arcing fault.

As stated, the foregoing conclusions are based upon operating data and results of the tests outlined in this article which were made upon cables buried in both relatively dry and in relatively wet soil, and others installed in relatively dry ducts. In addition to the conclusions already outlined the tests indicate certain other burn-off characteristics desirable in cables for use in a-c. low-voltage underground networks. Development of new insulating materials to provide these cables with such characteristics will require further research and experimentation.

Transient Voltages in Auto-Transformers

Effects of transient voltage phenomena upon auto-transformer design are discussed briefly. Results given are based upon tests.

By
K. K. PALUEFF General Elec. Co.,
Member A. I. E. E. Pittsfield, Mass.

GENERAL PRINCIPLES controlling the high-frequency voltage phenomena within auto-transformer windings are the same as those governing such phenomena in ordinary transformer windings. Since these principles have been discussed previously (A. I. E. E. TRANS., Vol. 38, p. 477; Vol. 48, p. 681; Vol. 48, p. 998; and Vol. 49, p. 1179) this should be looked upon as a continuation of that discussion and as written on the assumption that the reader is thoroughly familiar with the papers mentioned in those references.

To clarify the terms used, it should be noted that here:

1. The transmission line that brings a given surge to an auto-transformer is called the "primary line," while the other line of the auto-transformer is called the "secondary line."

2. The transmission line connected to the highest point of the auto-transformer winding is termed the "high-voltage line," while the line connected to the intermediate point is termed the "low-voltage line."

3. Part of the winding between the high-voltage and low-voltage lines is called the series winding, and the remaining part between the low-voltage line and ground is called the common winding.

ORDINARY AUTO-TRANSFORMER

In an auto-transformer two points of the winding are connected to transmission lines and it is this feature that makes the oscillation of an auto-transformer winding essentially different from that of an ordinary transformer winding. Because of the two independent transmission lines connected to the same winding, four different conditions of surge excitation are possible:

1. Surge arrives from high-voltage line.
2. Surge arrives from low-voltage line.
3. Two surges of the same polarity arrive simultaneously, one from each line.
4. Two surges of opposite polarity arrive simultaneously, one from each line.

The first two cases are the most common; the last two are rare because they may occur in two cases only, (1) when the lines are parallel and (2) when the lightning storm takes place directly over the auto-transformer.

SURGE FROM HIGH-VOLTAGE LINE

It is obvious that when a surge arrives from the high-voltage line the voltage distribution throughout the winding will be influenced by the potential rise of the low-voltage line arising from the surge transmitted through the auto-transformer windings. The magnitude and wave shape of the voltage rise of the secondary line depend upon (1) the shape of the incident wave, (2) the surge impedances of primary and secondary lines, (3) the effective inductance and turn ratio of the auto-transformer, and (4) the length of the secondary line. In most practical cases the rise of potential of the secondary line is slow as compared with the internal oscillation of the auto-transformer windings. Because of the finite length of the incident wave, and the rela-

---

From "Effect of Transient Voltages on Power Transformers—III—Non-Resonating Auto-Transformers," (No. 31-41) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

tion of the surge impedances and inductances found in practise, the ultimate potential of the secondary line is found to be a small fraction of the crest value of the incident wave of the primary line.

For these reasons the phenomena of oscillation of the series winding can be divided conveniently into two parts, (1) the rapid internal oscillations and (2) the relatively slow potential rise of the secondary line terminal. This permits the assumption that in most cases found in practise the secondary line acts as a solid ground for the internal oscillations produced in the windings by lightning disturbances originating on the primary line. Thus it may be said that the part of the winding between the terminals of the two lines oscillates as if the secondary terminal were solidly grounded. The part of the winding between the secondary terminal and neutral oscillates practically as a short-circuited secondary winding of a transformer, while the secondary terminal potential rises above ground at a substantially lower rate.

Practically full voltage of the incident wave appears across the series winding. In case the series winding has substantially fewer turns than the common winding, appreciable internal overvoltage may be created in the common winding by the step-up action due to mutual inductance between series and common windings. This fact is responsible also for the appearance of much higher voltages between turns of the series winding than would be found in transformer windings of the same voltage rating, or in the same auto-transformer with the low-voltage line disconnected. It follows that both of the effects mentioned may be particularly prominent in auto-transformers interconnecting transmission lines of closely similar operating voltages. The foregoing phenomena are characteristic of all auto-transformers.

Both amplitude and shape of secondary-line wave for any shape of incident wave on the primary line may be computed theoretically. Experimental study with different shapes of incident wave has confirmed the calculated results very satisfactorily.

With engineering accuracy it may be stated that, to the greatest part of the lightning wave as transmitted from the primary to the secondary line, an auto-transformer acts as an ordinary inductance connected between the two lines. The value of this inductance may be found by dividing the ohmic short-circuit reactance of the auto-transformer obtained at operating frequency, by 6.28 times the operating frequency.

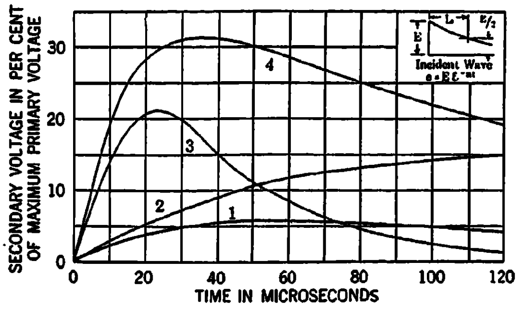
SURGE FROM LOW-VOLTAGE LINE

In this case an incident wave strikes the series and common windings simultaneously at their point of contact. Since the other end of the common winding is grounded permanently, and that of the series winding is connected to a transmission line, the oscillations of both windings are similar. This similarity, however, disappears in case of a substantial difference in the number of turns in the series and common windings. This happens because of the prominence in such a case of the step-up action referred to before.

SIMULTANEOUS SURGES

Cases of simultaneous surges are very rare; therefore no space will be devoted to their discussion here.

In case the high-voltage line is disconnected, an incident wave from the low-voltage line will cause the common winding to oscillate as a solidly grounded winding, and the series winding to oscillate as a winding completely isolated from ground, as was described in previous Institute papers. In case the low-voltage line is disconnected and the incident wave arrives from the



•Fig. 1. Curves showing voltage at low-voltage terminal of a transformer with incident wave applied to high-voltage terminal

1 and 3.—Length L of incident wave 20 microsec.
2 and 4.—Length L of incident wave 100 microsec.
1 and 2.—High effective auto-transformer inductance
3 and 4.—Low effective auto-transformer inductance

Long secondary line; surge impedance of both lines, 300 ohms; auto-transformer ratio 2:1. High effective inductance covers range from 20,000 kva., 220 kv. Y to 1,000 kva., 66 kv. Y; low effective inductance from 80,000 kva., 220 kv. Y to 10,000 kva. 66 kv. Y

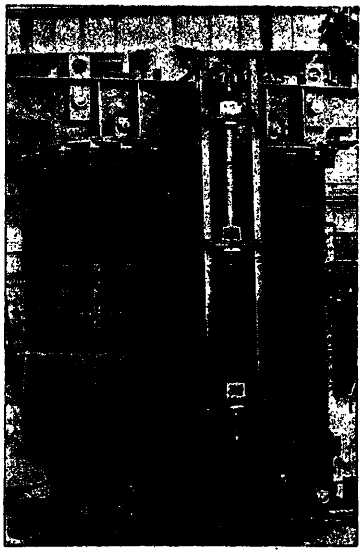


Fig. 2.
A commercial 20,000-kva. 215/107/11-kv. non-resonating aut transformer

high-voltage line, the entire winding oscillates as an ordinary transformer winding with solidly grounded neutral.

NON-RESONATING AUTO-TRANSFORMER

To reduce the danger associated with internal voltage oscillations, which cause abnormally high concentration of local stresses, a non-resonating auto-transformer has been developed and applied to practise. Tests have shown that it gives substantially uniform transient-voltage distribution. Underlying principles governing the construction are very similar to those which apply for non-resonating transformers.

The presence of two transmission lines connected to two different points of the winding causes some modification in the proportioning and distribution of shields as compared with that in a non-resonating transformer. In general appearance and construction, however, the non-resonating auto-transformer is very similar to the ordinary non-resonating transformer.

It is the author's opinion that the non-resonating auto-transformer is particularly well adapted to the concentric construction of windings typical of core-type transformers. Its windings are uniform mechanically as well as electrically, and free of the points of discontinuity and breaks which are characteristic features of interleaved windings. These breaks are points of extremely high voltage concentration. In spite of this fact, however, their dielectric strength often is made proportional to the test voltage produced across them during standard A. I. E. E. induced-voltage tests. Such grading of major insulation, of course, is not justified because in an ordinary auto-transformer, as contrasted to the non-resonating auto-transformer, the distribution of transient-voltage stresses does not correspond to the distribution of stresses created by standard low-frequency tests.

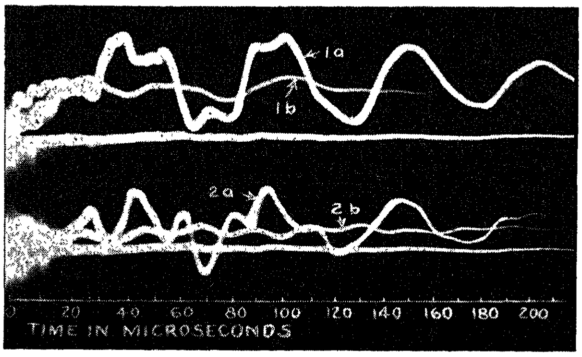


Fig. 3. Oscillograms showing internal voltages in a commercial non-resonating auto-transformer

1*a*.—32 per cent from neutral without shields

1*b*.—32 per cent from neutral with series and common windings shielded

2*a*.—12 per cent from neutral without shields

2*b*.—12 per cent from neutral with series and common windings shielded

Long rectangular wave applied to high-voltage terminal with low voltage lines disconnected. Tests made in air, thereby creating some electrostatic unbalance

CONCLUSIONS

Ordinary Auto-Transformer

1. With only one transmission line connected to an auto-transformer, a traveling wave produces internal oscillations similar to those produced in an ordinary transformer.

2. With both transmission lines connected to their respective terminals, a traveling wave impressed from one line creates two kinds of voltage transients in the windings; the first is relatively slow and responsible for the rise of potential on the secondary line; the second is relatively fast and consists of internal free oscillations in the windings.

3. For the internal free oscillation, a secondary line of sufficient length acts in most cases as a solid ground.

4. Internal stresses, particularly those between turns, are higher in an auto-transformer than in an ordinary transformer of the same voltage rating. This condition becomes aggravated as the auto-transformer voltage ratio approaches unity.

Non-Resonating Auto-Transformer

1. Auto-transformers can be built which are non-resonating for usual conditions of operation.

2. The windings of non-resonating auto-transformers are uniform and free of breaks.

3. Non-resonating auto-transformers are similar to ordinary non-resonating transformers in general appearance and construction.

An Improved Welding Generator

A neutralizing d-c. transformer removes troublesome transients from current output of welding generator.

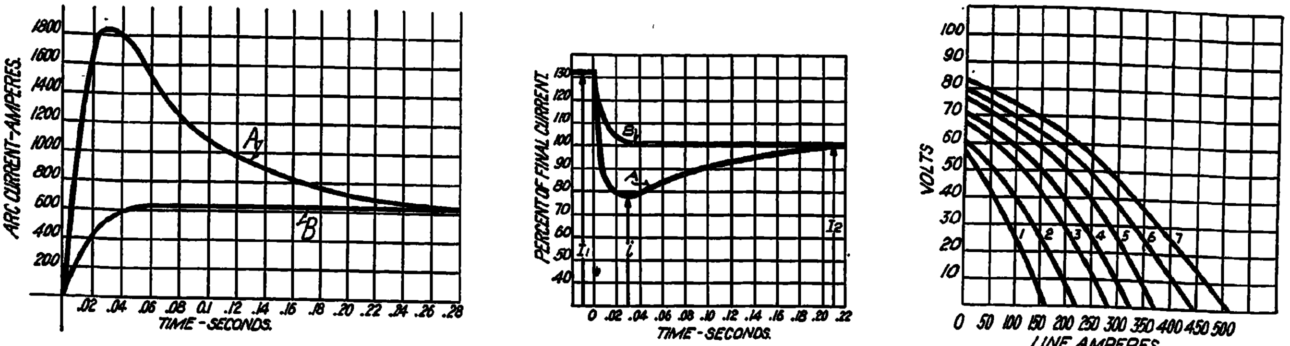
By
J. H. BLANKENBUEHLER

Westinghouse Elec. & Mfg.
Co., East Pittsburgh, Pa.

TROUBLES most commonly experienced with welding generators of inferior characteristic are (1) fusion of the electrode solidly to the parent metal upon contact and (2) frequent extinction of the arc by slight disturbances.

When contact is made between a new electrode and a cold plate neither should be melted until an arc is drawn; however, if the contact resistance and instantaneous short-circuit current are sufficiently high immediate fusion at the contact point will occur.

From "An Improved Arc-Welding Generator," (No. 31-13) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.



Welding current at short circuit on a typical welding generator. Curve *A*, ordinary design; curve *B*, with transforming reactor in field circuits

Welding current for sudden increase of voltage from 15 to 25 across the arc. Curve *A*, ordinary design; curve *B* with transforming reactor in field circuits

Family of curves for a 7.5-kw., 25-volt, 1,750-r.p.m. separately-excited differentially-compounded arc-welding generator

Fig. 1. Output current curves for typical arc-welding generators

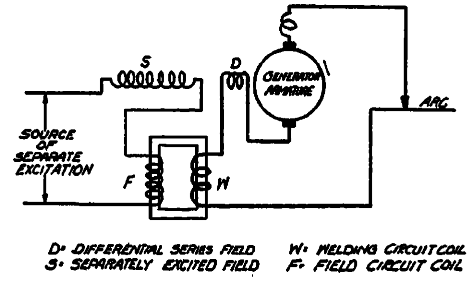
With the resistance thereby reduced, the molten spot solidifies and the electrode is "frozen." To obviate this difficulty it is necessary for a generator to have not only a low ratio of short-circuit current to welding current, but also to have no momentary current rise above the stable short-circuit value.

The operator's other annoyance, arc instability, is explained by the fact that in any particular arc there probably is a minimum value of current below which the arc will become extinguished. The actual value of such minimum current is dependent upon arc length, size and material of electrode and welded object, magnetic conditions about the arc, presence of flux or stabilizing gases, velocity of air blowing on the arc, and many other factors. Assuming this minimum current to exist, it can be said that any disturbance at the arc, which reacts on the generator so as to allow the current to drop below the minimum stable arc value, will extinguish the arc. To obviate this difficulty, then, it is apparent that the generator must accommodate changes arising from instantaneous variations in load (arc) resistance without permitting the delivered current to drop even momentarily below the minimum stable value.

Natural reactance within the welding circuit tends to overcome both difficulties by smoothing the welding current, and the addition of sufficient reactance to the circuit of course would approximate the desired results. An adequate reactance, however, would be large and prohibitive in power loss.

Practical experience, extensive tests, and numerous

Fig. 2. Method of connecting neutralizing transformer


S
D
GENERATOR ARMATURE
ARC
SOURCE OF SEPARATE EXCITATION
F
W
D= DIFFERENTIAL SERIES FIELD
S= SEPARATELY EXCITED FIELD
W= WELDING CIRCUIT COIL
F= FIELD CIRCUIT COIL

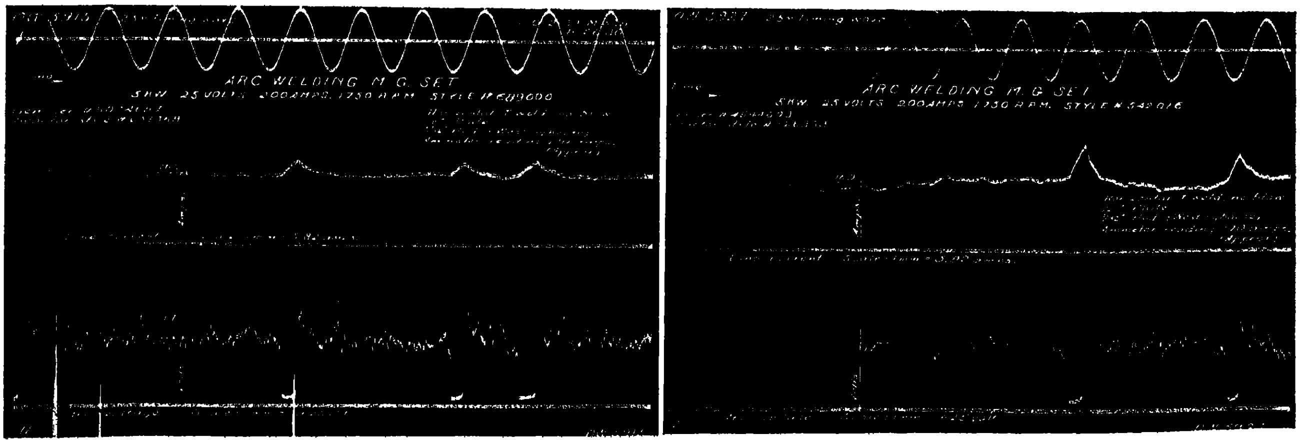


Fig. 3. Oscillographic record of a manual horizontal T-weld on 1/2-in. plate with 5/32-in. rod and 170 amperes and no magnetic blow (left) with neutralizing transformer and (right) with ordinary reactor

oscillographic records show conclusively that a generator having the short-circuit characteristics shown by curve B in Fig. 1 (left) and the arc-lengthening characteristics of curve B in Fig. 1 (center) produces a flexible and easily managed arc. The approximate constant-current volt-ampere characteristic best suited to a single-operator welding generator can be obtained most efficiently with a separately-excited differentially-compounded machine. Because of the current in the series field the voltage of this type of generator naturally follows the arc voltage for any given shunt-field current as a result of the inverse action of the series field. Typical curves are given in Fig. 1 (right). As previously implied, however, in addition to the ultimate steady-state condition it is imperative that the response be practically instantaneous in order to obviate the undesirable transients. In the ordinary design such rapidity of response is impossible because of the effects of magnetomotive force interlinkage among generator coils and the resulting transformer action. This delaying effect is demonstrated by the surge of curves A of Fig. 1 (left and center). Elimination of the surges requires that by the time the current builds up to its final value, the flux shall have changed to its final value.

Magnetomotive forces produced by currents induced in every conductor linking the flux retard the requisite change. Extensive tests have shown, however, that from a practical standpoint only the hindering effects developed within the field coils themselves are of sufficient magnitude to be important. Thus the problem reduces to that of preventing the development of undesired induced counter electromotive force within the field coils, or of neutralizing its effect by introducing into the field circuit an opposing voltage approximately equal at every moment to the instantaneous induced voltage.

The logical method of producing the required neutralizing voltage is to use a transformer with its primary in the welding circuit and its secondary in the field circuit as shown in Fig. 2. With the series field and the transformer primary in series, and hence carrying identical currents, any change in current will affect both at the same instant and the transformer secondary voltage will neutralize any voltage induced into the field coils as a result of the change.

Another feature of the system lies in the fact that by the proper proportioning of transformer primary and secondary the field current can be changed to induce a magnetomotive force which will promote the desired flux change; this force can be used to offset any retarding forces arising outside of the field coils. The device is equally effective in neutralizing the retarding effect of the field coils on any type of welding generator whether separately- or self-excited.

In addition to the ease of striking and maintaining a satisfactory arc with the described device, tests show a greatly decreased porosity of weld and improved efficiency in metal deposit.

A Telegraph Testing Machine

Telegraph line efficiencies and signal distortion measurements are only two of th many uses for this unique device. By means of an unusual electrochemical recorder, time intervals of one ten-thousandth of a second in the opening and closing of electrical circuits are graphically recorded.

By
F. B. BRAMHALL
Associate A. I. E. E.

Western Union Telegraph Co. New York

ANY MEASUREMENT of the quality of telegraph transmission is of necessity a measurement of the extent to which the received signaling pulses are distorted from the form in which they were originally transmitted. For the purpose of this article, signal distortion will be defined as the deviation in length and time relationship of the received signal pulses, from the absolute length and time relation of their transmission. This definition confines the measurement of distortion to the measurement of the time relationships which obtain between the signaling pulses as repeated by a relay or other repeating instrument. The unique arrangement of the electrochemical recorder of the transmission testing machine adapts it especially to the measurement of these time relationships.

A conception of the principle of the machine can be formed most readily if it first be considered as arranged for local testing of circuits both ends of which are available at the test point. Referring to Fig. 1, the commutator transmits signals to the circuit or apparatus under test. These signals operate a relay at the receiving end of the test circuit; the relay contacts control the potential applied between a metallic marking needle carried on an arm on the revolving shaft of the machine, and a metallic platen over which a saturated electrochemical recording tape passes. The arm which carries the marking needle revolves on the same shaft with the transmitting brushes, the revolving metallic marking needle making a light contact with the surface of the saturated paper tape. The chemical solution with which the tape is moistened and the material of the

---

From "Telegraph Transmission Testing Machine," (No. 31-17) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

marking needle are such that when the proper polarity of potential is applied to the needle a deep blue mark results from the electrochemical action. If in response to a transmitted signal pulse, the receiving relay energizes the marking needle during the time of its transit across the recording paper, a mark is made continuously until the needle is again deenergized at the termination of that pulse. Thus if transmission over the circuit under test be perfect, the revolving needle draws a line on the paper tape which is a true projection of the arc of the transmitting segment of the commutator. The recording tape moves at a slow rate; just sufficient to separate slightly the succeeding recorded marks.

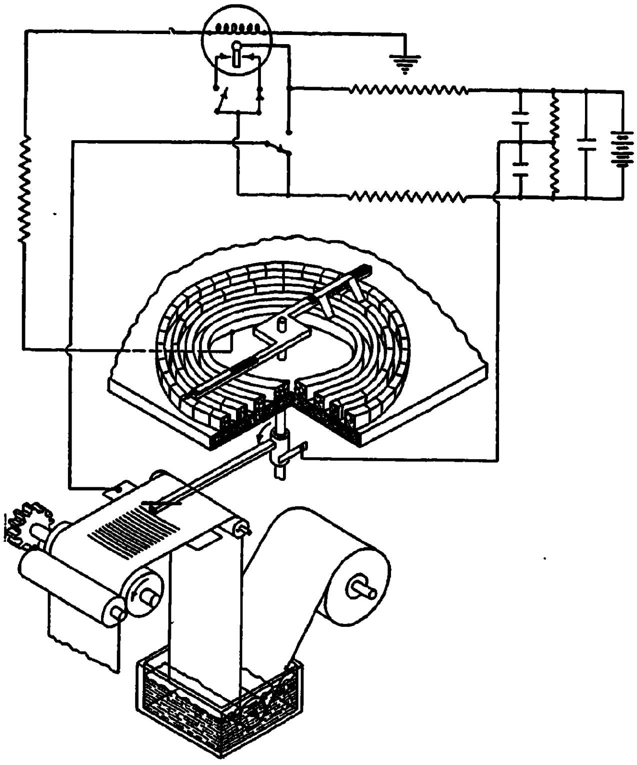


Fig. 1. Details of chemical recording mechanism. Note that recorder needle and commutator arm are mounted on the same shaft

Transmission and reception of signals by a common rotating member is obviously not essential in this method of measuring but may be performed by separate rotating members so long as proper synchronism of rotation is maintained. It is through the use of carefully synchronized transmission and reception that point-to-point testing is done.

In transmission measurement work of any kind it is common to use selected combinations of test signal pulses, either such combinations as represent certain letters in the signaling code or perhaps those which experience has shown are most susceptible to "fortuitous" and "characteristic" distortions. Fortuitous distortion is the shortening or lengthening of signal pulses which results from extraneous disturbing currents in the signaling circuit or from irregular and improper functioning of receiving or repeating instruments. Characteristic distortion is the shortening or lengthening of signal pulses, which is governed by the sequence of the pulses themselves and by the electrical and magnetic characteristics of the signaling circuits and apparatus.

For convenience, the transmission testing machine is equipped with a multi-point rotary switch which quickly sets up on the transmitting commutator any one of a number of predetermined test signal combinations.

Uses of the transmission testing machine in the analysis of signal distortions are most conveniently explained with the aid of sample records. Reproductions of typical records are shown in Figs. 2 to 5. In the more common classes of measuring work two test records are obtained, one showing the repetition from either contact of the receiving instrument. Through comparison of the two, bias of signals is either eliminated or quantitatively determined. Only one record is reproduced here in each case.

A record of substantially perfect transmission of signals repeated by a good polar relay operating in a

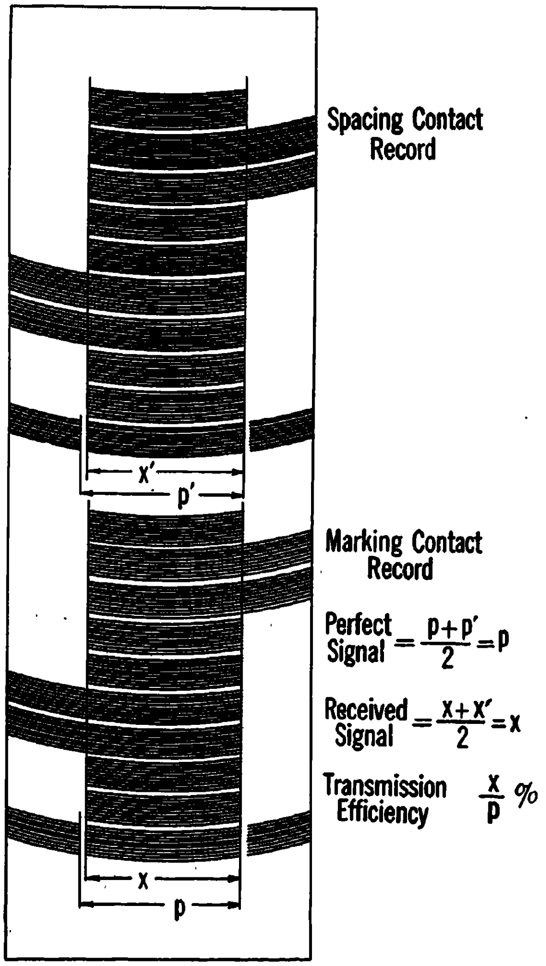

Spacing Contact Record
x'
p'
Marking Contact Record
Perfect Signal $= \frac{p+p'}{2} = p$
Received Signal $= \frac{x+x'}{2} = x$
Transmission Efficiency $\frac{x}{p}$ %
x
p

Fig. 2. Typical record of good polar relay operation

local circuit is shown in Fig. 2. At the bottom of this record is shown a short section made with the recording circuit so arranged that the marks are continuous except for the time that the relay tongue is not in contact with either of its stops. In this portion of the record the length of the breaks in the traces made by the recording needle is proportional to the "transit time" of the relay armature.

Typical performance of a poorer repeating relay is shown in Fig. 3. This record illustrates both a "transit time" loss and the loss due to the rebound or "chatter" of the tongue contact against its stop. A common form of characteristic distortion (that caused by a sluggish circuit or instrument) is shown in Fig. 4 together with a typical example of fortuitous distortion caused by a line disturbance. The periodic nature of this disturbance is evident in the regular beats produced in the received signals.

Records of over-all transmission in straightaway and field testing work are made by arranging the recording circuits so that the only traces made by the recording needle are those representing the open-circuit time of the receiving-relay contacts. These "negative" records convey the same information as do those of the other type and in this class of testing are generally preferred. They are desirable particularly where the test pulse combinations are of the nature of "traffic" signals.

The transmission testing machine finds a wide field of usefulness both in the measurement of over-all transmission efficiencies and in the analysis of transmission losses. It may be used as a monitoring recorder to check the distortion of "traffic" signals at either repeater or terminal points. Obviously it is not limited to the polar, two-element, class of signal work chosen for the explanation. It is as readily used for work on ocean-cable circuits employing a three-element code, and on neutral Morse or carrier circuits.

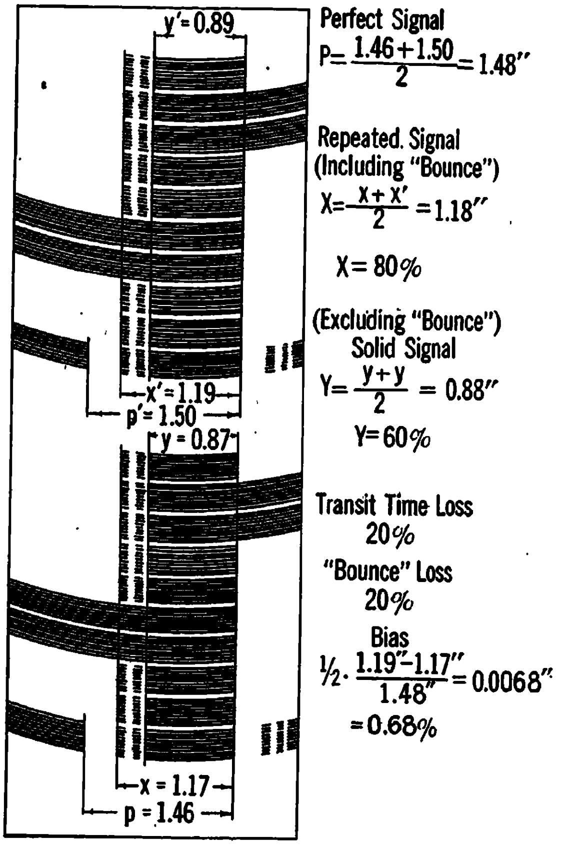


Fig. 3. Typical record of improper polar relay operation

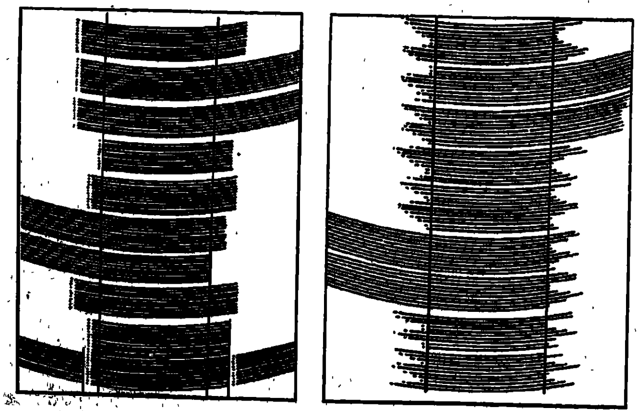


Fig. 4. Records of typical signal distortion; (left) "characteristic," (right) "fortuitous"

Average-Voltage Method for Transformer-Loss Measurement

By
ARAM BOYAJIAN
Fellow, A. I. E. E.
General Electric Co.
Pittsfield, Mass.

IN THE LATEST issue of the A. I. E. E. STANDARDS (May, 1930), Sec. 13, Par. 13-306, the following appears:

> "The no-load loss of transformers shall be determined preferably with a sine wave of applied voltage; if this is not practicable, the results obtained with a distorted wave of applied voltage shall be corrected to a sine-wave basis." And, foot-note: "For correcting to the sine-wave basis, method based on the measurement of average voltage is recommended."

The reason and basis for the adoption of this rule and recommendation by the A. I. E. E. is explained in the following discussion.

Unlike its load loss, the no-load loss of a transformer is very sensitive to wave shape and different test-voltage wave shapes cause radically different values to be obtained in its measurement. Therefore the no-load loss guarantee on a transformer means little unless the test result is reduced to a sine-wave basis.

Most of the no-load loss in a transformer is hysteresis loss. This is not a function of the *effective value* of the flux density or voltage, but is a function of the peak value of the flux density, which in turn is proportional to the arithmetic *average value* of the voltage. Peaked-voltage waves produce flat-topped flux waves and low-hysteresis loss, whereas flat-topped voltage waves produce peaked-flux waves and high-hysteresis loss. In commercial tests, the voltages usually become peaked and may lead to measurements which often are 10 and occasionally as much as 50 per cent too low. A no-load sine-wave voltage of a generator is no assurance of reliable results, because the distorted exciting current of the transformer under test usually materially distorts the terminal-voltage wave of the generator.

The amount of distortion caused by the transformer exciting current is roughly a function of the ratio of the transformer kva. rating to the generator kva. rating. Other factors that enter in are the percentage synchronous reactance of the generator, percentage field excitation of the generator, and the flux density of the transformer. To avoid objectionable distortion under such a load were no means of reduction to sine-wave basis used, the generator kva. rating would have to be much larger than the transformer rating. (With a dependable method of reduction to sine-wave basis, very much smaller ratios of generator capacity to transformer capacity may be used in such tests.)

Heretofore approximate correction for wave distortion has been made usually by means of a small auxiliary "standard" core calibrated on sine-wave voltage. This standard core is excited from the same source simultaneously with the transformer under test, and with the aid of its calibration curve a correction is applied either to the test voltage or to the wattmeter reading.

This method of correction for wave distortion, though infinitely better than the use of no correction at all, is not very satisfactory, because no standard core could be representative of sheet steel of all grades and types used, nor of the wide range of densities at which different transformers are designed to operate. Under unfavorable conditions the use of a "standard" core has been found to lead to errors of even more than 10 per cent.

Since hysteresis loss is not a fixed known function of density for all kinds of sheet steel at all densities, obviously the only way to assure correctness of the tested value is to maintain the correct maximum flux density. Mathematically it has been proved that the maximum flux density is proportional to the arithmetic *average value* of the voltage, and therefore that with an instrument reading the average value of an alternating voltage instead of its r. m. s. value, correct density in the transformer under test can be preserved irrespective of the voltage wave shape. If an average-reading voltmeter is calibrated on a sine wave or, more conveniently, on a d-c. source, and then is used to determine the test voltage, correct density and hysteresis loss in the transformer are assured. Results are practically independent of the type of core steel used in the transformer, and correction need be made only for the eddy-current component of the no-load loss. This is a relatively small correction and can be made very accurately.

The average-voltage method was not commercially practicable until a few years ago when G. Camilli showed how an average-reading voltmeter could be constructed using a vacuum-tube rectifier and d-c. voltmeter. Since the instrument was to be used for maintaining correct flux in a transformer it was named appropriately a "flux voltmeter." "A Flux Voltmeter for Magnetic Tests," A. I. E. E. Jl., October 1926, p. 989, disc. 1014.) Since then the instrument has been improved further by the use of a small copper-oxide rectifier instead of the vacuum-tube rectifier, and is available commercially.

In addition to the much greater accuracy obtained by the average-voltage method, there is the advantage that a given no-load-loss measurement can be checked very easily even in the field by any one using a flux voltmeter. The calibration of the instrument also is simple; it can be done on direct current.

Suspension Insulator Lifts 20-Ton Load

Westinghouse E. & M. Co. Photo

NEW developments such as railroad electrification with heavy cables tightly strung are demanding mechanical strength in insulators which requires all the designer's skill to furnish. Just as a demonstration of its strength this new 12-in. heavy-duty insulator, which is thought to be the strongest of normal type ever built, may be seen lifting a 20-ton steel car off the rails, trucks and all. The greater strength has been obtained not by using more material but by a more accurate knowledge of materials in general, and a more precise calculation of the distribution and transfer of stresses.

Insulation Research Advances Are Recorded

The quest for a better understanding of important problems underlying the improvement of electrical insulation is proceeding definitely through channels of research into related fundamentals, as outlined in the January issue of ELECTRICAL ENGINEERING (pp. 24-29). During the first half of 1931 some seven papers have been presented before Institute conventions and District meetings covering certain specific efforts in insulation research. Two of these papers concerned themselves with cable oils, two with impregnated paper, and three devoted primary attention to mathematical attacks upon insulation problems. In whole or in part in several instances these same papers were discussed at the Washington, D. C. meeting (Nov. 7-8, 1930) of the National Research Council's electrical insulation committee, which conference was comprehensively reviewed in the January 1931 issue of ELECTRICAL ENGINEERING. All of the papers in question have been reviewed briefly in current news reports appearing in ELECTRICAL ENGINEERING, but because of the importance of the subject and for the benefit of those it may serve, the following group of brief abstracts is published.

The Conductivity of Insulating Oils

By
J. B. WHITEHEAD
Fellow A. I. E. E.
Johns Hopkins University, Baltimore

CONTINUOUS-CURRENT characteristics of several insulating oils are studied for time intervals beginning 0.001 sec. after the application of voltage or short circuit. Essential equipment is the amplifier oscillograph in connection with a quick-acting switch. It is found that in one group of oils there is an initial conductivity which is constant over the period of the first second following the application of the voltage. Thereafter there is a slow decrease of conductivity to a final value much lower than the initial value. It is shown that this initial constant conductivity is sufficient to account for all of the dielectric loss under alternating stress.

In another group of more carefully refined and deaerated oils there is superposed upon the brief initial constant conductivity a still shorter initial evidence of dielectric absorption. During the first few thousandths of a second the charging current decreases sharply; is followed thereafter by a constant conductivity up to about one second, and thereafter decreases further to a much lower value after a long time. The initial absorption period has a corresponding discharge curve on short circuit. The measured value of the alternating loss in this case is completely accounted for by the sum of the loss due to the initial period of absorption in combination with the succeeding short-time-constant conductivity.

Other results are presented on the variations of the initial and final conductivities with the voltage and with temperature. The final currents show saturation characteristics, but the initial high conductivities do not.

Among the conclusions reached are the following:

1. Certain high-grade insulating oils have electrical characteristics similar in type and comparable in magnitude to those of the carefully refined poorly conducting liquids used in physical research.

Conductivities of the order 10^{-15} mhos per cu. cm. are common.

2. In the purest state they show a definite though brief dielectric absorption.

There are in fact three definite stages of conductivity: (A) an initial brief, rapidly descending value with corresponding curves for charge and discharge current, thus indicating the presence of dielectric absorption.

From "The Conductivity of Insulating Oils," (No. 31-40) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

The duration of this phase is of the order of 0.004 sec. (B) An approximately constant value of conductivity within the interval 0.004 to 1 sec. (C) A very slowly decaying conductivity reaching a constant value only after 30 min. or more.

3. Initial dielectric absorption increases with decrease of temperature and thus is associated with the viscosity.

It is difficult to measure at 60 deg. or in an oil slightly deteriorated. In these cases the absorption, if present, is obscured by the greater value of conductivity of stage (B).

4. Dielectric loss under 60 cycles alternating stress is determined definitely by the continuous-current characteristics, within the interval 0 to 0.1 sec.

Loss at the higher temperatures and for oils having high initial conductivity is accounted for completely by the conductivity of stage (B). For the purest and best oils below 60 deg. the alternating loss is accounted for completely by the conductivity of stage (B) plus the loss computed from the curve of dielectric absorption pertaining to stage (A). At 80 deg. this second component may represent 35 per cent of the total loss.

5. Initial absorption, conductivity, and subsequent decay are not completely accounted for by residual impurities, as frequently stated.

It is highly probable that they are due in part to the variety of molecular complexes and groupings occurring in such hydrocarbons, resulting in a heavy slow-moving type of ion which is subject to wide variation in properties with the value of the electric intensity and with other external influence. Thus these ions which give rise to the initial stages of conductivity probably are quite different from those involved in the final conductivity, and which have been used by Jaffe and others for drawing analogies between the conductivity of a liquid and of a gas. In fact there is no immediate evidence that this latter type of ion is involved in the alternating loss at commercial frequencies.

Some Electrical Characteristics of Cable Oils

By
HUBERT H. RACE
Assoc. A. I. E. E.
General Electric Co.
Schenectady, New York

ROUTINE measurements of d-c. resistivity are dealt with in the first part of this paper, along with a description of a quartz-insulated testing cell and a portable testing set for use with it. Absolute resistivity between 1×10^9 and 1×10^{13} ohms can be measured at any temperature up to 150 deg. cent. Among the conclusions are:

1. Data indicate that for comparative resistivity measurements it is necessary that the samples be thoroughly dry and that they be protected from light and heat before the measurements are made.

2. For comparing the electrical characteristics of commercial insulating oils, d-c. conductivity measurements are preferable to low-frequency bridge measurements since they give the same information and are easier to mak.

Variation of apparent d-c. conductivity of a heavy cable oil with potential gradient and with temperature are shown in the second part of this paper. Data show that the conductivity is constant only for very low gradients. An approximate mathematical relation is developed to represent the conductivity both as a function of potential gradient and of temperature. Measurement of the apparent d-c. conductivity of a heavy cable oil as a function of temperature and of potential gradient gave the following results:

1. Potential gradient must be kept below 20 volts per mil to assume constant conductivity for temperatures as high as 100 deg. cent.

2. The lower the temperature the higher the critical gradient below which conductivity is independent of gradient.

3. The lower the temperature the more rapid the increase in conductivity for gradients higher than this critical gradient.

4. Variation of apparent d-c. conductivity with both temperature and potential gradient may be represented approximately by the equation

$$\gamma = \gamma_0 \, \epsilon^{\alpha T} \, \epsilon^{\beta g}$$

in which, for the oil tested,

$\gamma_0 = 3.48 \times 10^{-23}$ mho. per cm.^{3}
$\alpha = 0.0683$ per deg. abs.
$\beta = 12.64\,(100/T)^6$ per volt per mil.
T = temperature in deg. abs.
g = maximum potential gradient in volts per mil.

5. In conducting those experiments, convection currents wer observed in the oil, indicating that the increase in conductivity at high gradients may result from increased mobility of charged aggregates.

Observed variations of dielectric coefficient and dielectric loss with temperature and frequency for a viscous cable oil are summarized in the third part of this paper. Analysis shows the total dielectric loss to be the sum of two components, one due to conduction and the other qualitatively explained by Debye's theory of polar molecules. On the basis of measurements made on carefully refined water-free mineral insulating oil through a temperature range from − 50 to 150 deg. cent. and a frequency range from 300 to 2×10^6 cycles per sec., it is apparent that:

1. At frequencies lower than 300 cycles per sec. and at temperatures greater than 25 deg. cent., the total dielectric loss may be accounted for by conduction only. Thus at 60 cycles per sec. it is only at very high viscosities that there is any appreciable loss except that resulting from conduction. For this reason d-c. conductivity measurements are sufficient in comparing the electrical characteristics of insulating oils, when made according to conditions discussed in Part I of this paper.

2. At higher frequencies and lower temperatures the conduction loss becomes small compared to an a-c. loss which may be qualitatively explained on the basis of Debye's theory of polar molecules. While it is true that Debye's theory has given qualitative agreement with observed data, it is possible that similar relations may be developed on the assumption of the motion of charged particles in an ionic atmosphere.

3. In mineral oils having lower-viscosity, but about the same conductivity, this a-c. loss is negligible at even lower temperatures and higher frequencies than for the more viscous oil.

4. For oils containing larger amounts of polar constituents, such as castor oil or oil-rosin mixtures, this a-c. loss may be appreciable even at commercial frequencies and temperatures.

5. Data indicate that it is dangerous to draw conclusions as to the characteristics of a material from measurements taken only for narrow ranges of experimental conditions. Studies over wide ranges of frequency and temperature may explain apparent discrepancies between results of different experimenters working within different limited ranges of measurement.

From "Some Electrical Characteristics of Cable Oils," (No. 31-47) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

Fundamental Properties of Impregnated Paper

By
J. B. WHITEHEAD
Fellow A. I. E. E.

W. B. KOUWENHOVEN
Member A. I. E. E.

Both of Johns Hopkins University, Baltimore

FIRST results are given in this discussion covering a study of the separate electrical behavior of the paper, the impregnating oil, and the combination thereof which constitutes impregnated insulating paper. Where possible, efforts were made to determine the relationship existing between fundamental and final characteristics.

The materials used constituted two essentially identical paper specimens and two oil specimens drawn from the same batch. The paper samples were carefully dried prior to testing; one of the oil specimens was used "as is" and the other was deteriorated by heating in the presence of air until its dielectric loss and conductivity were approximately double that of the other specimen. All specimens were tested separately; subsequently combinations of the paper specimens with the two different oil samples were tested.

Test procedure involved the use of both continuous and alternating potentials for the determination of temperatures ranging from 30 to 60 deg. cent. Short-time oscillograms and long-time values of charge and discharge currents were measured using continuous potentials; power factor, capacitance, and dielectric loss were determined with alternating potentials. All of the a-c. loss in the paper specimens can be accounted for by absorption, while the dielectric losses in the oils can be accounted for entirely by the short-time conduction and brief initial dielectric absorption.

The two impregnated-paper specimens were found to be alike, in that their voltage-power factor curves were straight lines and that their losses increased in proportion to the square of the test voltage. Some noteworthy differences, however, are worth mentioning:

1. The shape of the loss-temperature curve for the paper specimen impregnated with the poorer oil had a U shape, while the other showed a curve that was falling over the entire range of temperature studied.

2. Although initially both paper specimens had the same capacitance, the one impregnated with the poor oil of high conductivity and lower dielectric constant had a greater resulting capacitance than the other which was impregnated with the good oil of low conductivity, but of greater specific inductive capacity.

3. Dielectric loss in both impregnated specimens was greater than the sum of the individual losses in the paper and oil used in their production and may be completely predicted from the short-time continuous-voltage records.

4. Electrical characteristics of paper are changed by impregnation. The reversible absorption and the irreversible charging current both are increased by the conductivity of the oil.

The differences in the characteristics of the two impregnated specimens were due to the differences in the initial conductivity of the two oil samples. The dielectric loss in the specimens has been analyzed and separated into three components; reversible absorption, irreversible conduction current, and final conductivity. The loss due to short-time conduction may be as high as 30 per cent of the total loss, and 250 times the loss as computed from the final conductivity.

From "Fundamental Properties of Impregnated Paper," (N . 31-45) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

Air and Moisture versus Paper Insulation

By
J. B. WHITEHEAD
Fellow A. I. E. E.

F. HAMBURGER, JR.
Assoc. A. I. E. E.

Both of Johns Hopkins University, Baltimore

THIS is the third of a series of studies into the still open question of the influence of residual air and moisture upon the properties of impregnated-paper insulation. The influence of residual moisture was found to be universally bad and increasing amounts of such moisture are immediately reflected in higher values of power factor and loss and in other evidence of instability. One of the most striking results of the earlier studies was the relatively small effect of residual air upon the shape of the voltage-power factor curves. The shape of these curves was not appreciably affected in the range of evacuation pressure from 1 to 10 cm. Hg. abs. and furthermore the curves were flat up to 300 volts per mil and 50 deg. cent. Only at impregnation pressures above 25 cm. Hg. do the typical rising power factor-voltage curves become evident. Upon dissection, dryness and gas voids always were associated with rising power factor-voltage curves, and apparently-excellent impregnation with the flat curves.

The present paper presents the results of studies of the influence of residual air upon the life of the finished insulation. The value of the pressure of evacuation and impregnation was used as a measure of the amount of residual air. The test sample consisted of a brass tube 1 in. in diameter and 4 ft. long upon which were wrapped 15 layers of 0.0043 in. manila cable paper 1

From "Residual Air and Moisture in Impregnated-Paper Insulation —III," (No. 31-95) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

in. wide. In all respects excepting certain modifications for strengthening the ends to withstand the higher voltages requisite for the accelerated life test, the sample was similar to that used in the earlier studies.

In view of the influence of residual moisture, all the samples were dried to the same standard value of d-c. conductivity before impregnation and then evacuated and impregnated at various values of pressure as a measure of their air content. The usual program in the accelerated life test was to start at 400 volts per mil, followed by 500 and 600 volts per mil at 1-hr. intervals, thereafter advancing to 600 and 650 volts per mil at 10-hr. intervals, followed by 700, 750, 800, 850 volts per mil for increasingly long periods. This program resulted in a life in the neighborhood of 12 hr. for the poorest specimens, but in several cases of better grade, the life reached a week and more without sign of distress at prolonged periods of 850 volts per mil. In these tests the temperature remained constant at 40 deg. cent.

A summary of the conclusions is as follows:

1. The life of impregnated-paper insulation increases steadily with a decrease in the amount of residual air.
2. For impregnating pressures above 2.5 cm. the life decreases rapidly with increasing pressure of impregnation. For pressures below 2.5 cm. the results show an increase of life of from 10 to 50 per cent between 2.5 cm. and 2 mm. impregnating pressure.
3. For impregnating pressures below 2.5 cm. normal variations in material and structure, particularly in the tightness of the structure, may offset the increased life due to decreasing the pressure of impregnation.
4. Cable compound deteriorates if it contains only a small amount of air, even though it is kept in sealed containers at room temperature. Air should be entirely excluded to avoid deterioration.
5. Flat power factor-voltage curves and the absolute value of power factor should not be accepted as indications of long life.
6. Power factor rise due to the initial application of voltage during a life test is indicated as a possible criterion of insulation life.
7. A very satisfactory type of sample and reenforced cable-end for accelerated life tests has been developed.
8. Narrow variations in the quality of both paper and oil may cause wide differences in the electrical characteristics and in the lives of the impregnated products.

Insulation Variability

By
M. C. HOLMES
Assoc. A. I. E. E.

West Virginia University, Morgantown

THIS paper constitutes a theoretical investigation of the effect of insulation variability in determining the breakdown voltage of systems containing large areas of insulation, or large numbers of units of insulation in parallel. It is based upon the idea that a failure in the insulation of a system, like that of a chain, depends upon the strength of the weakest part, or unit; and that the greater the number of units in a system and the greater the variability among the units the greater will be the likelihood of a failure. The analysis, therefore, makes use of the laws of probability which incidentally are more exact and of greater practical importance than is generally believed.

That the results of the investigation may be immediately applied and tested in engineering they are given in the form of two general equations. These two equations give in terms of two parameters either the breakdown voltage of a system or the number of failures to be expected. The parameters are (1) mean breakdown voltage and (2) variability of the units of insulation of which the system is composed, both determined from tests made on samples. The paper shows how the results may be applied to the special case of electric power cables for comparing the relative merits of different cables and for determining the factor of safety required to take account of the inherent variability of the insulation. A graphical method of analysis also is described which makes use of a special kind of graph paper called "probability" paper. In the case of cables the probability coordinate is changed from "per cent" to "failures per 100 miles of cable per year."

The two general equations, and the meetings of the symbols, are as follows:

$$F = N\left[1/2 - \mathrm{erf}\left(\frac{1 - E_o/E_a}{S}\right)\right] \tag{1}$$

and

$$E_b = E_a\,[1 - S\,.\,\mathrm{erf}^{-1}\,(1/2 - 1/(2\,N))\,] \tag{2}$$

The first equation gives the number of failures F to expect in a system containing N units of insulation at an operating voltage E_o, the units being assumed removed from the system upon failure. The two parameters E_a and S may be considered as representing the quality of the insulation as regards resistance to rupture, E_a being the mean breakdown voltage of the units and S the coefficient specifying the variability of the insulation. The second equation gives in terms of the same two parameters the breakdown voltage E_b for a system of N units of insulation connected in parallel.

The symbol *erf* is an operator used to denote the Gaussian error function, the value of which may be obtained from tables similar to tables of sines and cosines. The symbol erf^{-1} represents the inverse operation just as the symbol sin^{-1} represents the inverse of *sin*. Values of $erf(x)$ and $erf^{-1}(x)$ may be obtained from tables, then, just as are values of $sin(x)$ and $sin^{-1}(x)$ The equations therefore are quite simple and easy to apply in spite of their formidable appearance.

The coefficient S, specifying the variability of the insulation, is calculated from the results of breakdown tests on samples. It is the standard deviation, sigma, expressed as a decimal fraction of E_a. Sigma is defined by the following equation:

$$\text{sigma} = \sqrt{\frac{\Sigma\,(\delta)^2}{n}} \tag{3}$$

where $\Sigma\,(\delta)^2$ represents the sum of the squares of the deviations of individual breakdown voltages from their mean, and n is the number of test results considered.

The two equations are entirely general. Specific equations may be obtained from them and applied to all kinds of insulation, either in the form of continuous areas as in cables, or in the form of discrete units as in

---

From "Insulation Variability—Its Influence in Determining Breakdown Voltages," (No. 31-99) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

overhead transmission lines. In the former case N represents length of cable measured in terms of some standard test length; in the latter case, N represents the number of units of insulation under voltage stress, for example the number of strings of insulators along an overhead line. In the case of thin sheets of insulation N may be taken to represent electrode area; equation (2) then gives breakdown voltage as a function of electrode area as well as insulation variability. It therefore constitutes a distinct advance over the well-known equation of Milnor's which takes account only of the effect of area.

In the past too much attention has been paid to mean breakdown stresses or to the extremely high stresses exhibited by a few samples of insulation, and not enough to the question of variability. The present paper shows that the variability is at least equally important, and often is the *more* important because it is the strength of the weakest unit—not the mean strength of all the units—which determines the strength of the entire system.

Thermal Breakdown of Solid Dielectrics

By
P. H. MOON
Member A. I. E. E.

Massachusetts Institute of Technology, Cambridge

THE purpose of this paper is to correlate the work which has been done on thermal breakdown and to put it in a form in which it can be used by the electrical engineer in the calculation of breakdown voltage. Besides a treatment of the Fock theory, the paper includes the derivation of new formulas for breakdown of very thin and very thick samples and for internal temperature rise and current.

A startling fact brought out by this analysis is that before breakdown the internal temperature never rises more than about 10 deg. cent. above ambient temperature.

The three Fock tables of breakdown voltage are extended to cover a wider range of temperature and all thicknesses, and the results are put in several forms convenient for numerical calculations. Breakdown voltage hitherto has been calculated by a tedious cut-and-try process using all three tables. In the present paper this has been simplified and the results given in the form of new curves and tables, thus greatly reducing the labor required for breakdown calculations. Experimental data are presented to verify the theory.

From "The Theory of Thermal Breakdown of Solid Dielectrics," (No. 31-83) presented at the A. I. E. E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

Equivalent Circuits of Imperfect Condensers

By
C. L. DAWES
Member A. I. E. E.

W. M. GOODHUE
Non-member

Both of Harvard Engineering School, Cambridge, Massachusetts

IMPERFECT condensers usually are represented by equivalent electrical circuits consisting either of a pure capacitance and a resistance in series or by a pure capacitance and a resistance (or conductance) in parallel. Algebraic relationships existing among these circuit parameters are well known and commonly are used in dielectric study and electric circuit computations. For most dielectrics the equivalent series and parallel capacitances are essentially equal; in this paper examples are given where this is far from true.

The purpose of this paper is primarily to show quantitatively the application of these equivalent series and parallel circuits to composite dielectrics consisting of solid dielectrics and ionized gases in series, and more particularly to high-voltage cables having degrees of ionization varying from practically zero to very high values.

With a composite dielectric consisting of a slab of glass in series with a film of ionized gas the equivalent series resistance for the fundamental component of current varies with the current density and, so far as heretofore has been known, its characteristic was merely a curve more or less indefinite in character. In this paper it is shown that this characteristic is a definite and relatively simple function of the current density and that it has a maximum value which is readily computed from the constants of the composite dielectric.

The characteristics of high-voltage cables hitherto have been given in terms of equivalent series and parallel capacitance and in terms of equivalent parallel resistance. The equivalent series and parallel capacitances in most cases are practically equal; even for

---

From "Equivalent Circuits of Imperfect Condensers," (No. 31-74) presented at the A. I. E. E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

values of power factor as high as 12 per cent they differ by only 1.5 per cent.

The equivalent parallel resistance and conductance and the equivalent series resistance of cables having ionization hitherto have been expressed by curves which seemed to have had no analytical basis. In this paper, however, it is shown that such curves (with the exception of the region of successive ionization) can be expressed by relatively simple analytical equations; also the curves of the equivalent parallel conductance and equivalent series resistance can be analyzed into three simple component curves. Moreover, at the ionization voltage these curves rise rapidly to a maximum and then decrease more slowly. This maximum value and the voltage at which it occurs are readily calculated, being very simple functions of the characteristic cable contants. These curves also are shown to be very similar to the power factor curve and to differ from it by only a coefficient $C\,\omega$ that is nearly constant.

Thus this paper puts on a moderately accurate quantitative and analytical basis what hitherto have been merely cable curves having no apparent relationship to the inherent cable constants.

Equivalent series and parallel parameters of ionized gas films taken by themselves also are analyzed, with only the fundamental component of current considered. It is shown that the equivalent series resistance of such films may be expressed fairly accurately by a simple equation, and that the characteristic has a definite and sharp maximum which is easily computed.

Unlike cables, the equivalent series and parallel capacitance of ionized gas films differ radically from each other in value. At large current densities the value of the equivalent series capacitance may be as high as six times the value of the equivalent parallel capacitance. Hence the two cannot be assumed to be equal as with ordinary cables and other dielectrics. The equations for the characteristics of an equivalent series capacitance can be determined from the characteristic curves themselves, but thus far it has been found impossible to relate them to any fundamental electrical property of the ionized gas.

Oscillograms show that with a sine-wave voltage the current in ionized gas films consists largely of harmonics, particularly those of high frequencies. It is emphasized in the paper that these harmonics render ambiguous many of the definitions which hitherto have been applied to dielectrics. Also most high-voltage bridges measure only the fundamental component of voltage and current. Hence it is recommended that for simplicity both in definition and in measurements, quantities relating to ionized gas films shall be defined for the present with reference only to the fundamental component of the current and voltage waves.

Water Power Exploitation in Switzerland

Switzerland is one of the few countries fortunate in having at its disposal more water power than its inhabitants can use conveniently. Hydroelectric power now is supplied to 90 per cent of the total population and to 98 per cent of all municipalities.

SWITZERLAND'S topographic, geographic, and economic situation contributed to bringing about the early and extensive utilization of the country's electric energy, not only for its railways but for various industrial and other purposes requiring motive power, says Prof. C. Andreae, engineer E. P. F., former rector of the Federal School of Technology at Zurich and now director of the Royal School of Technology at Guiseh (Egypt), in an article published recently in *Swiss Industry and Trade.*

A marked industrial development has taken place during the past century in Switzerland due primarily to the growing inadequacy of agricultural products to provide for the maintenance of its ever increasing population. Switzerland possesses no coal mines. Its rivers and waterfalls, however, are a source of great natural wealth and their exploitation has become a vital economic factor.

The total amount of this natural energy is estimated at 6,000,000 kw. and is capable of producing an annual output of 20,000,000,000 kw-hr. At the present time only 1,550,000 kw. is being utilized, the annual production amounting to 5,968,000,000 kw-hr. Nevertheless, in 1925 consumption had reached 820 kw-hr. per capita of inhabitants, without exports; including the latter the total per capita output exceeded 1,000 kw-hr. As would be expected from these facts there are surprisingly few people in Switzerland who do not enjoy to some extent the benefits of electricity, statistics indicating that 90 per cent of the total population and 98 per cent of all municipalities are supplied with this commodity.

The total area of Switzerland measures only 15,990

Contributed by F. Dossenbach, director of the Official Information Bureau of Switzerland, New York. Not published in pamphlet form.

sq. mi., or about twice the area of the state of New Jersey. This comparatively small area, however, embraces great differences in altitude, the highest point being 15,200 ft. above sea level; the lowest, 646 ft. Consequently declivities are extremely pronounced and stream beds exceedingly abrupt.

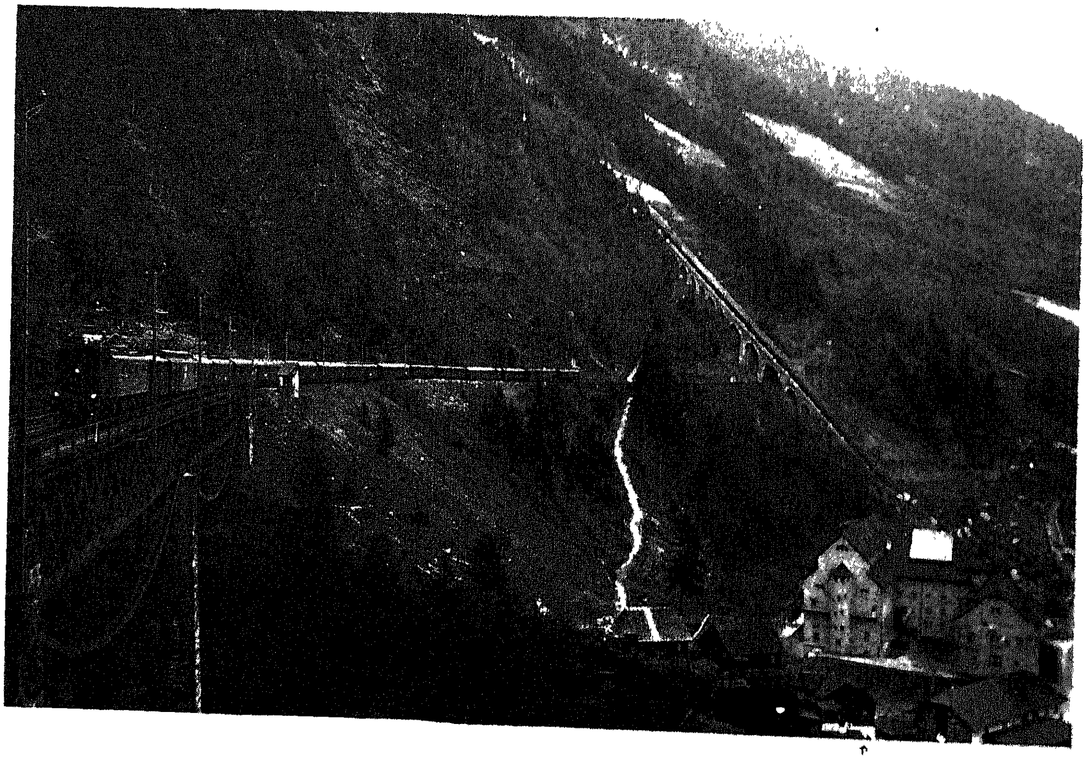
Judging from these facts, the prevalent conditions for hydroelectric development would appear to be favorable and simple. Switzerland's hydrologic régime, however, is peculiar; although 60 per cent of the precipitation occurs during the five winter months (November-March) and only 40 per cent during the seven summer months (April-October), rivers and streams are high in summer and low in winter. This is because winter precipitation takes place generally in the form of snow and remains stationary until the summer months. Consequently the energy produced directly in winter constitutes only one third of that obtained during the summer.

An exactly opposite situation exists as regards consumption and demand. Maximum consumption during a winter day is about 120 per cent of the average daily consumption throughout the year; for a summer day, the maximum is about 80 per cent of the average. An economical exploitation of this natural energy then obviously necessitates some measure to compensate for the divergency between output and consumption. Among the various methods advocated, the system of hydraulic accumulation during the summer, when output exceeds consumption, has proved the most economical and enjoys the greatest popularity.

Similar to the situation existing in the mountainous regions of western United States, accumulation is effectuated by means of dams allowing for the retention of the water during the summer. Accordingly, plants are constructed in the vicinity of the Alps where small streams with high heads produce relatively large quantities of electric energy with comparatively little water. Some plants have been constructed also on the lower portions of rivers and streams to utilize directly the heavy summer stream flow. During the summer months, these plants supply practically all demands, allowing those situated in the higher Alpine regions to fill their accumulation basins in preparation for the annual low-water period.

Considered from economic and financial points of view, these groups of power plants are not all organized upon the same basis. The Swiss Confederation owns the plants which supply tractive power for the state railways only. A small number are owned by the cantons or municipalities while others are operated by private companies. The most important groups, however, are owned by "mixed companies." These are limited companies in which the larger portion of the stock is in the hands of the cantons or municipalities. This combination, wherein private capital cooperates with public effort, has given excellent results in the majority of cases.

What will be the largest "accumulation" plant in all Europe is now under construction on the River Aare at Grimsel Pass. It will have two basins with a total capacity of 91,600 acre-ft. The principal dam will be 361 ft. high. Water is to be utilized in three instalments, with a total fall of 3,940 ft., and the ultimate plant capacity will be 250,000 hp. At present only the first instalment which will aggregate 120,000 hp., is being built. The waterfall for this initial development will be 1,770 ft. high, and the rate of flow, 642 sec-ft.



An excellent example of Switzerland's rugged topography showing a train of the electrified St. Gothard railway approaching the huge Kerstelenbach viaduct. At the right may be seen the Amsteg hydroelectric plant with its three penstocks running down the mountainside

News
Of Institute and Related Activities

And Next—The Tahoe Convention

The program has been published (pp. 514-6 ELECTRICAL ENGINEERING, July, 1931) and circulated to every member of the Institute; committees have been as busy as the proverbial bees gathering proverbial honey; Tahoe Tavern beckons with special reduced rates; the majestic Sierra Nevada await; Lake Tahoe is ready; and prospective speakers are (or undoubtedly should be) practising before favorite mirrors. In other words, the stage is all set for a most attractive Pacific Coast convention at Lake Tahoe, California, during the last week in August.

As hinted before, the forthcoming events offer opportunities attractively unique in the variety of things those in attendance may do, in addition to participating in a good technical program. Just to mention a few, there's hiking, fishing, boating, swimming, golfing, and Reno. And then there is the fact that transportation rates from many points are the lowest that they ever have been. Last, but not least, there is the cordial invitation of General Chairman A. W. Copley (vice-president-elect) to "come and bring the family."

Kansas City is Host to October Meeting

The South West District No. 7 of the A. I. E. E. will hold a three-day meeting at Kansas City, Missouri, October 22-24.

Four technical sessions have been tentatively scheduled, the first of which will comprise papers on a variety of subjects: building-construction welding, relay operation as affected by wave form, pilot-wire relaying, computing currents in network loops, backfires in rectifiers, overvoltages due to the dropping of load, and surge tests on a distribution substation. The three other sessions will include papers on: St. Louis-Bagnell interconnection, communication, and transmission and distribution. At the interconnection session a three-reel motion picture of the actual construction of the Bagnell dam will be shown.

In addition to the foregoing technical program there will be two student sessions at one of which papers by the students will be presented.

Other features of the program will consist of entertainment, inspection trips, and recreation. These will be announced in detail in a subsequent issue of ELECTRICAL ENGINEERING, together with a full listing of the papers to be presented.

Officers, Delegates, and Members Hold Animated Sessions at Asheville

Following the plan inaugurated in 1930, the conference of officers, delegates, and members, held under the auspices of the Sections committee and the committee on student Branches, met on Monday and Tuesday afternoons, June 22 and 23.

The attendance of official delegates was larger than ever before; representatives included 52 of the 59 Sections, all of the ten District secretaries, and counselor delegates from eight of the nine Districts in which committees on student activities have been organized. Institute and Section officers, Branch counselors, and other members present brought the total attendance to about 110.

After a brief opening session on Monday afternoon, sessions A and B were held in parallel, Everett S. Lee, chairman of the Sections committee, presiding over session A devoted to Section activities, and Prof. W. J. Seeley, a member of the committee on student Branches, presiding over session B which dealt with problems concerning the Branches and enrolled students of the Institute. Tuesday afternoon was devoted to a joint meeting of the two groups to discuss subjects of common interest.

The topics in a conference program, which had been mailed to delegates and others in advance, are given in the following outline:

Monday, June 22, 2 p. m.

1. Opening of conference:
   Announcements by Everett S. Lee, chairman of the Sections committee.
2. Remarks by W. S. Lee, president.
3. Remarks by C. E. Skinner, president-elect.
4. Remarks by F. L. Hutchinson, national secretary.
5. Division into parallel sessions of Section and student Branch delegates and members.

Session A—Sections Meeting—Everett S. Lee presiding.

6. The Institute Membership—J. Allen Johnson, chairman membership committee.
   a. The licensing or registration of engineers.
   b. Establishing a high professional standing of engineers in civic and other affairs.
   c. How to create an interest in members of six or more years standing in transferring to the grade of Member or Fellow.
7. Conduct of Sections—H. H. Henline, assistant national secretary.
   a. Finding new material for officers.
   b. Types of programs and speakers; frequency of meetings.
   c. How to build up and maintain interest of members in sections by technical and entertainment programs, and social features.
8. Finances—A. C. Stevens, secretary, District No. 1.
   a. Financing of Sections and District meetings.
   b. Financing of Section contact with local engineering societies.

Session B—Student Branch and Enrolled Student Meeting—Prof. W. J. Seeley presiding.

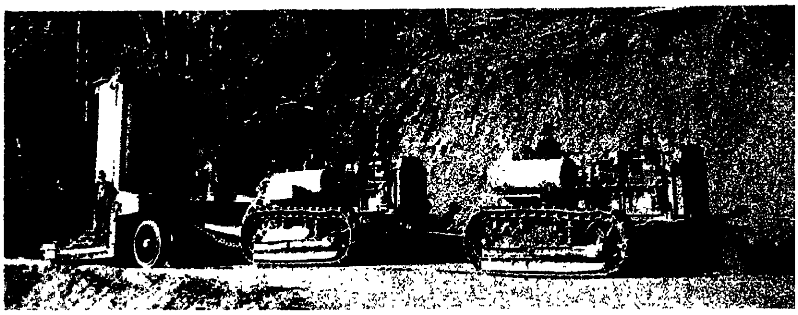
9. The problem of interesting the better high school students in electrical engineering—Prof. W. H. Timbie, chairman committee on student Branches.
10. The most advantageous time of year for holding student conferences—Prof. Joseph Weil, counselor delegate, District No. 4.
11. Coordination between the Branches and Sections, national organization, and practising engineers—Prof. G. H. Sechrist, counselor delegate, District No. 6.
12. Conduct of Branch business—Prof. G. L. Hoard, counselor delegate, District No. 9.
13. Financing the chairmen of the District student Branch committees—Prof. D. C. Jackson, Jr., counselor delegate, District No. 7.

Tuesday, June 23, 2 p. m.

Session C—General—Everett S. Lee presiding.

14. The Institute and the student—Prof. W. H. Timbie, chairman committee on student Branches.

Transportation in Electrical Construction



SINCE those in attendance at the Pacific Coast convention at Lake Tahoe, California, will have the opportunity to visit the recently completed Tiger Creek plant of the Pacific Gas and Electric Company on the Mokelumne River, it is of some interest to note the contrast in transportation facilities available for this latest job as compared with those available for the company's early De Sabla plant built on the same stream in 1904.

- a. How to get the facts regarding the electrical engineering profession before juniors and seniors in high schools.
- b. Cooperation between local Sections and student Branches.
- c. Meetings of local Sections conducted by younger engineers.

15. General.
    - a. The extension of the scope of A. I. E. E. activities to include more of "the economic aspects of engineering" and "engineering views on non-engineering subjects."
    - b. Index of engineering literature as now published in **Electrical Engineering**. To what extent is it used? Should it be extended or condensed?
    - c. Questions and answers in general.

Copies of the annual report on Section and Branch activities for the fiscal year ending April 30, 1931 were distributed. These may be secured without charge to Institute members by applying to headquarters.

During the discussion on Section activities it was agreed that the Sections committee will consider the problems of such Institute members as are interested in a particular Section but located either in the territory of another Section, or outside the territory of any Section.

RECOMMENDATIONS ADOPTED

A resolution was adopted recommending to the board of directors that,

1. A national standing committee on transfers be created consisting of five members.
2. A local committee on transfers of three members be created in each Section.

The conference voted hearty approval of the recommendations of the committee on student Branches as reported by Chairman Timbie, for supplying information regarding electrical engineering as a career to high school teachers and students.

A motion was adopted recommending to the board of directors that the allowance of traveling expenses for visits of the vice-presidents to Sections and Branches in their Districts be increased is feasible, in order that a vice-president may be able to make many visits without incurring a considerable personal expense.

Decisions of the counselor delegates upon subjects not considered by the conference as a whole are summarized below:

The time of year at which District conferences on student activities should be held should be selected by each District according to its needs.

While some outside speakers are desirable, generalizing, the Branches should have very few.

The counselor of each Branch should instruct new officers regarding their duties and should insist that the Branch secretary report all meetings to headquarters.

The appropriation of $200 per year was recommended to defray the expenses of postage, stenographic service, etc., required by the chairmen of the District committees on student activities.

An abstract of the proceedings of the entire conference will be printed in pamphlet form and mailed to all delegates present; also to Institute, Section, and Branch officers. Any member of the Institute may secure a copy without charge by applying to headquarters.

"Slide Rule" for Lamp Calculations

As part of its development and educational campaign directed toward improved illumination efficiency, the Nela Park engineering department of the General Electric Company, Cleveland, Ohio, has issued recently a simple combination celluloid-and-cardboard slide rule. This device is designed to reveal the voltage-operating characteristics of electric lamps and to simplify the analysis of the economics of incandescent lighting. For any voltage condition the calculator makes easy the determination of the quantity of light that will be produced, the quantity of energy consumed, and the lamp life, thus showing at just what point the most light may be obtained for the least total cost.

With the improved quality of lamps now available, and the low prices prevailing, Nela Park states that generally the cost of current represents approximately 90 per cent of the cost of light under average conditions. Thus a variation of 1 per cent in lamp efficiency is as important as a range of 10 per cent in lamp price. The slide rule reveals quickly that operation of an incandescent lamp at slightly under voltage appreciably increases the lamp life, but also reduces lighting efficiency to a point which brings the total cost of illumination to a figure several per cent higher than would prevail if the lamps were operated at rated voltage. The lamp-characteristic calculator is available through the sales offices of the Edison Lamp Works and the National Lamp Works of the General Electric Company.

Summarized Review of Some Summer Convention Discussions

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized; complete discussion together with all of the papers will be published in the Transactions. The titles of the papers and the names of their respective authors were published in Electrical Engineering, May 1931, pp. 370-1.

Communication Services for Electric Utilities

H. S. Phelps, in his discussion of this subject, stressed the importance of high quality of voice transmission on the part of the system devoted to the use of system load dispatchers. He explained also that considerable "transmission margin" should be provided to assure good communication in the event of system expansion or the emergency of rerouting communication circuits.

F. R. Innes discussed the use of a remote metering system, quickly responsive to changing load conditions, to communicate to one point and to one man a complete "picture" of the system load. Such a system would facilitate load division between stations and result in a more stable system operation.

Electrical Machinery

L. P. Shildueck discussed "Reestablishing Excitation of a Loaded Alternator in Parallel with Others," pointing out that to prevent damage to the rotor excitation should be reapplied as soon as possible. He analyzed the conditions resulting when a turbine generator upon loss of excitation runs as an induction generator above synchronous speed at some slip determined by the governor setting. At a condition of 2 per cent slip, rotor losses would be 1,500 per cent of normal and high body currents concentrated at the ends of the machine might burn the rotor wedges and cause considerable damage. For these reasons excitation and operation at synchronous speed should be reestablished very quickly; otherwise the machine should immediately be disconnected from the line.

L. L. Perry discussed this same paper with particular reference to the application of the facts presented to the triple-compound unit comprised of one high-pressure generating unit and two low-pressure units. In the event of accidental opening of the high-pressure generator field the prompt reestablishment of excitation (instead of opening the circuit breaker and admitting high-pressure steam to the low-pressure turbines) would result in considerably less momentary loss to the system and in quicker restoration of the load previously carried.

M. L. Henderson discussed "Calculation of Synchronous-Machine Constants," and analyzed the formula for end-winding leakage which he found yielded results comparable with those obtained by different methods. In conclusion he expressed hope that the nomenclature for machine dimensions, number of phases, number of slots, etc., used by different designers would arrive at a steady state. This would save a great deal of the user's time when comparing with the results of another writer.

H. Poritsky discussed "Field Transients in Magnetic Systems," and suggested an equally illustrative yet simpler example than the one given in the paper. In place of an iron core he suggests a yoke of width w considerably larger than the thickness t. A case is obtained which results in a one-dimensional problem in the heat equation, and from which the Bessel functions would be eliminated in favor of hyperbolic or circular functions.

Automatic Stations

M. E. Reagan discussed "An A-C. Supervisory Control System" and its proposal to use alternating current from the supply lines for supervisory control. This fact resulted in each case in the ultimate abandonment of similar systems proposed during recent years. He believed, however, that the system has several novel features which will tend to increase the reliability factor and that only time will give a true comparison to the storage battery systems.

F. H. Hollister read a discussion by T. G. Robinson on "Automatic Combustion Control," which verified the practise and results given in the paper. It also was explained that of late there has been a desire to eliminate multi-speed induction motors used to drive draft fans. This has led to the application of variable-speed Rossman drives for draft fans. Recent tests and analysis of one boiler installation in the Chicago area indicated an approximate 4 per cent overall increase in efficiency which corroborates the statement in the conclusion of this paper.

I. M. Stein also discussed this subject and made a plea that installations be kept as simple as possible rather than following the tendency to make them complicated just because automatic controls can handle complicated installations. He urged that station auxiliaries should be designed or selected with the requirements of automatic combustion control fully in mind.

M. C. Reagan discussed "Operating Experience with Automatic Control" with reference to the argument in the paper that in general, maintenance charts are not good for getting a complete, accurate record of operation. He believes that this may depend largely upon the type of form used. Some operators have found this to be the one method of obtaining good maintenance records.

One of the points discussed by C. E. Stewart in connection with this paper was the use of the mono-wire or direct-wire system. He believes that this system for short distances over privately owned wires is undoubtedly the most economical in first cost. Whether the sacrifice in flexibility to meet future rearrangement of the supervisory equipment due to changed operating conditions, future growth, etc., offsets this advantage is questionable and must be determined by local conditions. Maintenance of automatic equipment also was ably discussed by Mr. Stewart who pointed out that today more time is spent on preventative maintenance. Mr. Stewart also discussed miniature switchboards stating that considerable advance has been made in the design of suitable control keys and meters so that now the miniature switchboard is considered a standard type of board for installations in power and switching stations. They effect improved operating conditions and economies.

M. C. Reagan discussed miniature switchboards pointing out that the statement regarding increased intervals between maintenance periods corresponds to the experience of a great many operating companies. He cited that where equipment is kept in near-dust-proof cases, less maintenance yields better results.

Symposium on Interconnections

H. K. Sels discussed the papers presented in this symposium and in particular he would like to see the definitions in the paper entitled "Interconnection Services—Their Classification and Evaluation," accepted as standard. He pointed out that one engineer refers to "load diversity" where another calls it "peak diversity;" "economy flow" also is called "dump power." Furthermore, in contractual relations, accepted definitions would provide useful terms in writing contracts which would have a better legal status.

H. G. Harvey discussed the same paper saying that with a few very obvious modifications the main service divisions outlined in the paper could be applied to reactive kva. as well as to true power flow or kilowatts. In further discussion Mr. Harvey called attention to a momentary emergency service caused by a surge originating on one system affecting the other. In some cases this condition has been a source of difficulty, and so far as is known no means have been devised to adjust for it equitably.

M. M. Samuels in discussing the same paper from the executive standpoint emphasized the importance of engineers submitting to executives economic answers rather than engineering answers. He cited and explained five items in systematic form which he thought should be presented to them for each year of each plan after the evaluation studies suggested by the author had been completed.

L. L. Perry in his discussion of "Interconnections" cited some of the advantages which accrue from the operation of widely interconnected systems, such as lower fixed charges, better operating economy, more uniform frequency, lessened voltage fluctuations, and better service reliability. He also expected that rapid developments with simultaneous automatic frequency-control equipment would be made, and he discussed the use of transformer phase-control equipment.

S. S. Seyfert called attention to the economic and social aspect of interconnections. He cited that the numerous interconnections already effected or in the making have created a new situation calling for a fuller degree of integration than now exists. If the public could be educated as to the advantages and attractive possibilities of interconnection and integration, and if the facts of which engineers are aware could be expressed in their own terms without technical language, the public would be influenced to stand behind and support integrated power systems, financially and otherwise, as they have done for other worthy projects in the past.

INTERCONNECTION—NEW ENGLAND DISTRICT

A. H. Sweetnam described several of the interconnections made with the Boston system. All important transformer banks involved in these interconnections now are equipped for tap changing under load and are supplemented by synchronous condensers. Phase-angle control equipment also is being contemplated. Particular emphasis was placed on one of the points mentioned in the paper: the importance (to the successful operation of any interconnection) of a mutual spirit of cooperation and good will regardless of formal contracts.

H. R. Kurth told of the operating problems of the Boston system in relation to its interconnection, and of some of the mutual advantages which accrue from such operation. Interconnections of ample capacity have permitted operation for maximum over-all economy of the several systems without loss of their corporate identities. In conclusion he stated that the spirit of cooperation between the several system operators is paramount in New England.

ELECTRICAL UNITS

H. B. Brooks discussed "Electrical Units and Their Application." He was in agreement with the author that electrical units should not be arbitrary if agreement with the fundamental units is to be maintained. He also told of a development by Doctor Silsbee to meet the demand in the a-c. field for a new type of instrument. It operates directly on the electrodynamic principle and can be wound as wattmeters, ammeters, or voltmeters, with a reading error equivalent to that of a pointer instrument having about 1,250 scale divisions.

In relation to the part of the paper pertaining to length measurement, H. W. Bearce calls attention to an important step taken in 1927 by the international committee on weights and measures by which a supplementary definition of the meter was set up in terms of light waves.

L. T. Robinson in his discussion of the subject expressed gratitude for the degree of precision attained by the Bureau of Standards in the absolute determination of the ohm. He hoped that some equally satisfactory arrangement might be made with regard to the volt.

H. L. Curtis in a discussion for Doctor Brooks summarized information which will probably be available to the international committee at its next meeting in 1933.

STANDARD CELLS

L. T. Robinson commented on the fact brought out in Eppley's paper that the permanence of standard cells is much more satisfactory than their reproducibility in absolute values. If the absolute value of the ohm and the volt is adopted and if such progress is made with the volt as has been made with the ohm, the only requirement for working reference standards will be their permanence and transportability.

W. B. Kouwenhoven explained a simple, inexpensive, and fairly satisfactory method to reduce variations caused in standard cells by unequal temperature changes. They can be protected with heat-insulating material such as a two-inch layer of cork which gives good results.

H. B. Brooks discussed the use of standard cells and means of comparing them. He expressed favor for the opposition method, by which one actually measures only the small difference between the e. m. f. of the cell under test and that of the reference cell. He explained that he had under design special potentiometer for standard-cell comparisons which is based on the opposition method but has novel features which avoid two small inconveniences of the method, mentioned by Doctor Eppley.

DESIGN OF POTENTIOMETERS

G. Thompson discussed the use of low-resistance and high-resistance potentiometers. He pointed out that it would be a mistake to draw the conclusion from the paper "Design of Potentiometers," by I. Melville, that the high-resistance potentiometer no longer has its place in voltage measurements; or even that it is inherently less accurate and reliable than the low-resistance types. Long experience has shown that gradual changes to take place in the resistance of the slide-wire, due to wear from the sliding contact near the ends of the wire. On the other hand, high-resistance potentiometers have retained their initial accuracy without repair.

H. S. Brooks discussed several points brought out in the same paper. He stated that absolute stability in the coils of a potentiometer is unnecessary; the requirement being that the various coils of any given potentiometer should maintain their relative values to a suitably high degree. In connection with taking account of parasitic e. m. f. by using a false zero setting of the galvanometer, as suggested by the author, he points out that there are cases, such as in the comparison of standard cells, where this method is not reliable.

Doctor Eppley discussed this paper and he believed the author had overestimated the difficulty of making 1,000-ohm coils constant to 0.01 per cent, and that he had underestimated the difficulty of making lower-valued coils of the same consistency. He said that he had known sealed 1-ohm coils, so enclosed as to be protected against humidity changes, action of oil, etc., to vary by more than 0.02 per cent; while on the other hand, he had checked many instruments having 1,000-ohm coils of the ordinary non-enclosed type which remained constant to 0.01 per cent.

N. E. Bonn in his discussion of this subject explained why he takes exception also to the author's discussion of the superiority of the low-resistance potentiometer over instruments having a high internal resistance. He also briefly discussed the modification of the White potentiometer shown in Fig. 6 of the paper. In calculating the maximum errors that may arise from the manipulation of dials and switches, he did not believe the author's assumption that compensation would always remain accurate to 0.01 per cent.

Cables

G. B. Shanklin discussed "Economics of High-Voltage Cable" calling attention to the fact that since the paper was written, there has been a still further reduction in the cost of 66-kv. oil-filled lines. This has been accomplished by a reduction of insulation thickness from 0.40 and 0.42 in. to 0.35 and 0.375 in., representing approximately a 25 per cent reduction in the cost of oil reservoirs, and an increase of from 70 to 75 deg. cent. in guaranteed maximum copper temperature.

W. B. Kouwenhoven discussed this paper with reference to the improvement in power factor with time shown in Fig. 31, and the fall in the ionization factor shown in Fig. 32. He explained that in his work improvement in power factor has been noticed following impregnation, which improvement continued over a considerable time before reaching a constant result. This was accounted for by a lowering of the initial conductivity of the impregnated material, possibly due to absorption of ions by the paper or to some other reason not understood.

W. A. Del Mar discussed this subject and called attention to several points made in the paper. With regard to the lower cost of 66-kv. single-conductor oil-filled cables as compared to the cables of the ordinary type, he pointed out that this conclusion applied only to the flat topography of Chicago. Concerning the simplification of oil-filled cable he believed that shipping-reel reservoirs for cables impregnated with liquid oil at the factory constituted an essential feature.

J. B. Whitehead in his discussion of this subject asked Mr. Roper whether credit for increased stability and life of the oil-filled type might not swing the comparison of the 66-kv. single-conductor cable more definitely to the oil-filled type and perhaps extend the economic oil-filled range even lower in the scale of load and voltage values.

Characteristics of Oil-Filled Cable

D. D. Higgins read a discussion of this subject prepared by K. W. Miller and F. O. Wollaston, which gave reasons why they preferred to solve the oil-flow and temperature-transient problem by well-known methods of elementary differential equations instead of the Heaviside operator used by the authors.

W. A. Del Mar discussed the papers on oil-filled cables and stressed the importance of the high dielectric strength over long periods of time rather than the "breathing" property, explaining how this was attained. In conclusion he indicated the two different methods used by the authors to obtain an open passageway between the reservoir and the hollow core without weakening the joint, and stated that the industry will watch with interest the performance of these two ways of solving the problem.

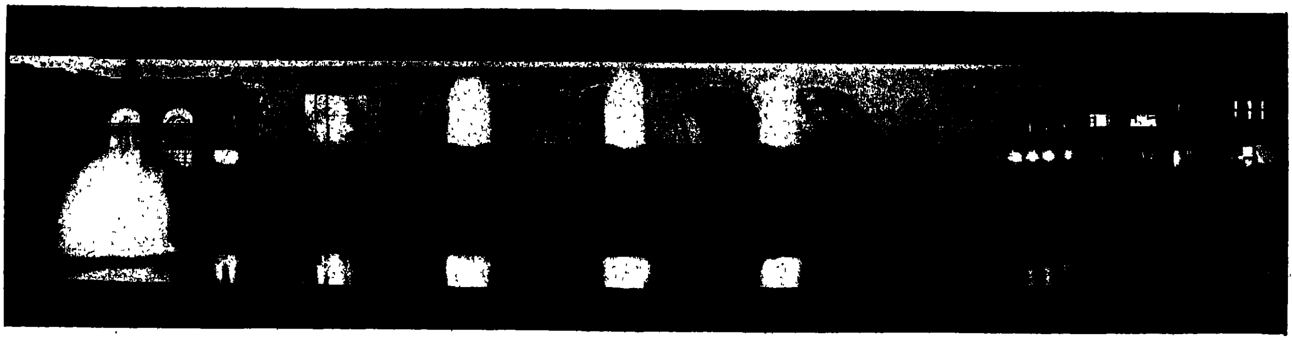
G. B. Shanklin discussed the condenser principle of joint and terminal designs brought out in the paper by Atkinson and Simmons. He believes there are undoubtedly possibilities in the use of this principle. However, to meet existing competition the designs must prove equally good, or better, electrically and mechanically and be of equal or lower cost. Compactness is an important factor to be considered. In his opinion, the condenser principle was more applicable to stop-joints than to normal joints and terminals.

Impregnated-Paper Insulation

G. B. Shanklin discussed the paper on this subject saying that he does not believe the results obtained could be reliably used as a practical guide for factory production methods. He is of the opinion that high vacuum during the drying operations is not the entire answer, as far as the removal of initial factory impurities is concerned.

A part of W. A. Del Mar's discussion in connection with this paper described an investigation made recently by J. H. Palmer showing by means of Lichtenberg figures the effect of corona on test voltage. The results as a whole did not show a definite increase in figure diameter with corona. Deviation from a mean was a maximum at the 60- and 80-kv. points, amounting to 0.04 "and 0.03" respectively, or 3 kv. If the very considerable amount of corona used in these tests had no appreciable effect on the voltage, the shortened cable lives noted by the authors

Spectacular Floodlighting at Wanaque Dam



THIS installation consists of 1,600 ft. of floodlighted dam with a slope of 210 ft. below which five electric fountains play, three of them 35 ft. high and 25 ft. wide studded in red, amber, blue, and green lenses and floodlighted by 36 underwater 1,000-watt projectors grouped twelve to a fountain and two smaller pool fountains 15 ft. high and 10 ft. in diameter, the red, blue, green, and amber lenses floodlighted by ten 500-watt underwater lamps. This is the recently completed Wanaque Dam of the North Jersey District Water Supply Commission, fronting eleven acres of attractively landscaped grounds, the roadway lighted with twelve 1,000-watt projectors effectively mounted on roof corners of the various buildings, the dam itself lighted with fifty 1,000-watt lamps mounted on pump house and service buildings to create an impressive appearance of the eleven massive arches silhouetted against the dark green of the brass beneath them and crowned with the white expanse of the main structure. W. T. Blackwell (A'22) general lighting representative of the Public Service Electric & Gas Company, Newark, N. J. was consulting illuminating engineer in charge for the Commission. (Contributed by G. S. Merrill (M'12) W. T. Blackwell (A'22) Public Service Electric & Gas Company, Newark, N. J., through the A. I. E. E. committee on the production and application of light.)

must be due to some kind of resonance effect.

W. A. Del Mar also read J. H. Palmer's discussion which described the design details of a cable terminal with a reinforced end having a logarithmic flare designed to withstand the higher test voltages.

E. M. Clark's discussion also was read by W. A. Del Mar; several suggestions were offered for consideration. A single stock sample of impregnating liquid of medium viscosity was used for several years, and no deterioration of liquid either in its chemical or physical or electrical properties has been noted. The liquid, however, was protected from light with no special precautions aside from the usual oil drum seal. It was suggested that the authors give further description of the physical and electrical characteristics of the compound which they have used.

H. S. Burd in discussion of this same paper pointed out that impregnation and vacuum pressures used would have to be quite different for cable manufacturing methods where large masses are concerned than where miniature apparatus and small samples are handled. He further indicated methods of improvement for the manufacture of solid types of cable paralleling the improvements in the oil-filled cable.

R. W. Atkinson discussed "Insulation Variability" pointing out that the paper has made the laws of probability conveniently available for use in the study cable insulation. However, in further discussion, limitations of the author's method of attack on practical cases were cited and errors in some of the assumptions indicated.

RESEARCH AND SELECTED SUBJECTS

D. C. Prince discussed "Extinction of Short A-C. Arcs" stating that no mention was made of some prominent arc characteristics, such as the rectifying effect of arcs in general and of metal-vapor arcs in particular. He described phenomena which should tend to explain the marked difference in behavior of low- and high-melting materials noted by the author. He believed the cathode-spot phenomena a predominant role in explaining the behavior of short a-c. arcs.

W. B. Kouwenhoven discussed "A Corona Tube Voltage Regulator" showing that the authors have described a voltage regulator which apparently is quite simple and without moving parts. He asked if it were possible to employ the system for the control of frequency, and requested the authors to give a complete circuit diagram, assuming the source of supply to be a 115-volt a-c. generator driven by a d-c. 230-volt motor.

R. H. Park discussed "Experimental Studies of Arcing Faults" commenting upon the method of measuring voltage. He claimed that with a potentiometer resistance of 500,000 ohms, the instrument itself might have an appreciable effect on the oscillations which develop during the arcing period. Thus the potentiometer may have prevented the occurrence of some of the phenomena which were under investigation.

J. K. Peck in his discussion of this same subject analyzed the results of some tests on a 140-kv. system. Out of eighteen oscillograph operations the highest overvoltages recorded varied from 1.2 to 2.6 times normal peak voltage-to-ground. In no case did cumulative oscillations appear in the voltages during the fault. Oscillation durations ranged from 4 to 112 cycles. A typical oscillogram of one of these faults was shown and it is believed that these records are a valuable supplement to the paper.

COOPERATIVE EDUCATION

W. E. Freeman discussed this subject giving several reasons why it would be undesirable to apply such a system of education to state universities. As influencing difficulties he cited (1) large enrolments where engineering students are given fundamental instruction in other colleges of the university and (2) the usual small-community location of these universities, remote from industry.

S. S. Seyfert discussed the subject inquiring if the courses of the cooperative scheme could not be so planned that the two systems could be economically operated in parallel in a department of moderate size. He also asked about the difficulties encountered when a student desired to transfer from one plan to the other.

D. C. Jackson discussed the subject comprehensively and analyzed the value of the paper. So far as comparative results of the two plans are concerned, he pointed out that because of the many incomparables in the situation it is difficult to draw conclusions. He believes 25 years a suitable period to set up for observation in such educational matters before drawing full, ultimate conclusions.

A. I. E. E. Directors Hold June Meeting at Asheville

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the Grove Park Inn, Asheville, N. C., Wednesday, June 24, 1931, during the annual summer convention of the Institute.

There were present: *President*—W. S. Lee, Charlotte, N. C. *Past-presidents*—R. F. Schuchardt, Chicago, Ill. *Vice-presidents*—H. V. Carpenter, Pullman, Wash.; H. P. Charlesworth, New York, N. Y.; H. S. Evans, Boulder, Colo.; T. N. Lacy, Detroit, Mich.; I. E. Moultrop, Boston, Mass.; W. S. Rodman, Charlottesville, Va.; G. C. Shaad, Lawrence, Kans.; C. E. Sisson, Toronto, Ont. *Directors*—A. E. Bettis, Kansas City, Mo.; F. C. Hanker, East Pittsburgh, Pa.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; E. B. Meyer, Newark, N. J.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. *National treasurer*—W. I. Slichter, New York, N. Y. *National secretary*—F. L. Hutchinson, New York, N. Y. Also, present by invitation, were: L. T. Robinson, Schenectady, N. Y. *Assistant national secretary*—H. H. Henline, New York, N. Y. *Officers-elect*—C. E. Skinner, East Pittsburgh, Pa.; L. B. Chubbuck, Hamilton, Ont.; W. E. Freeman, Lexington, Ky.; B. D. Hull, Dallas, Tex.; W. B. Kouwenhoven, Baltimore, Md. *Past-presidents*—Dugald C. Jackson, Cambridge, Mass.; P. M. Lincoln, Ithaca, N. Y.; Charles F. Scott, New Haven, Conn.

The minutes of the directors' meeting of May 19, 1931, were approved as previously circulated.

A report was presented and approved of a meeting of the board of examiners held June 5, 1931, and upon the recommendation of that board the following actions were taken upon pending applications: 67 Students were enrolled, 117 Associates and 25 Members were elected, 35 applicants were transferred to the grade of Member, and five to the grade of Fellow.

Approval by the finance committee for payment of monthly bills amounting to $27,132.62 was ratified.

A progress report was presented embodying several recommendations of the special committee on Institute policies which had been appointed in accordance with action taken at the May meeting of the board of directors. (A statement regarding the functions of this committee was published in the July issue of ELECTRICAL ENGINEERING.)

Upon the recommendation of the special committee on Institute policies and with the concurrence of Chairman Kidder of the committee on the engineering profession, a resolution was adopted "that in view of the large number of important matters that would ordinarily come before the committee on the engineering profession, the work should be divided, and the name of that committee should be changed to 'committee on legislation affecting the engineering profession;' also that a new standing 'committee on the economic status of the engineer' should be appointed."

Consideration was given to the draft of a constitution prepared by the electrical advisory committee of the American Standards Association, for an "electrical standards committee," which was proposed by the A. I. E. E. in February 1930 to function as a joint agency in the electrical industry and as an integral part of the American Standards Association, for the purpose of carrying out the standardization activities of that industry. The board voted its approval of the proposed constitution.

The president was authorized to appoint a successor to the late Edward D. Adams as one of the Institute's representatives upon the engineering societies library board.

Recommendations to the board of directors adopted at the conference of officers and delegates held at Asheville, June 22-23, were presented and referred to appropriate committees for consideration.

Upon petition, and with the approval of the chairmen of the Sections and the finance committees, the board authorized the organization of a Montana Section of the Institute.

Consideration was given to a draft of a small pamphlet containing information on electrical engineering for high school students, to assist them in deciding whether or not to prepare to enter this profession, the board at a previous meeting having made an appropriation to cover the cost of printing. It was voted to approve the draft of this pamphlet for printing.

Resolutions were adopted expressing the board's appreciation of the services of the members of the Asheville convention committees; also extending to the newspapers of North Carolina appreciation of the effective publicity given by the press to the Asheville convention.

Other matters were discussed, reference to which may be found in this and future issues of Electrical Engineering.

"American Bells" of Louvain in Summer Concert

The Louvain carillon, of French, English, and American fabrication, and rising 140 ft. above sea level, will celebrate a continuation of the international ceremony by which it was presented July 4, 1928, by a series of concerts during the summer, at which Kamiel Lefavere, Belgian cailloneur of the Riverside Church, New York will officiate. In a letter to Dr. A. D. Flinn, director of Engineering Foundation, Prof. Van Essen, secretary general of the University of Louvain has said, "These bells regulate our academic life as well as that of our citizens . . . through the University's office, they are governing the time-table and occupations of the whole city." Recent appointment of Paul Van Zeeland, professor of economics, University of Louvain, to the American Engineers Memorial Committee has been announced by the Hoover Foundation for the development of the university.

1931 Lamme Medal Nominations Close October 1

In fulfilment of By-Law requirements second posting is hereby given to the necessity of all nominations for the Lamme Medal for 1931 being submitted not later than October 1, 1931. (See Electrical Engineering, June 1931, p. 446.)

Presentation of the 1930 Lamme Medal was duly made to W. J. Foster, consulting engineer, General Electric Company with suitable ceremonies at the opening session of the Institute's recent summer convention, Asheville, N. C.

Library of Congress Available for Wide Service

Collections of matter published in the various branches of science and available for public use in the Library of Congress, Washington, D. C., are far more extensive and comprehensive than seems to be generally understood, according to Dr. H. W. Tyler, consultant in science at that library. Facilities for research by both individuals and groups, a system of inter-library loans, and a card index service covering some 965,000 titles, are among the services available.

In addition to the strictly library service, according to Doctor Tyler there now are seven consultants: one each in science and philosophy, economics, and sociology; and three in literature and history. The function of these consultants is described as "interpretation," and assisting in forming outside contacts with specialists or various authorities in specialized fields. Engineers interested in the possibilities of using the Library of Congress service may obtain information relating to specific fields by corresponding with Doctor Tyler.

A. I. E. E. Lamme Medal Presented at Asheville

In keeping with the established custom the Lamme Medal of the American Institute of Electrical Engineers for 1930 was presented to Dr. William James Foster (F'16) at the summer convention in Asheville, N. C., with appropriate ceremony, Monday morning June 22, 1931. Instead of the custom previously followed of making the presentation in connection with an evening dinner meeting, this year it was made one of the first orders of business at the opening session, an arrangement in keeping with the importance and dignity of the occasion, and meeting with the heartiest approval of assembled delegates. As previously mentioned (Electrical Engineering, March 1931, p. 230 and July 1931, p. 519) the award was made for Doctor Foster's "contributions to the design and development of rotating electrical machinery."

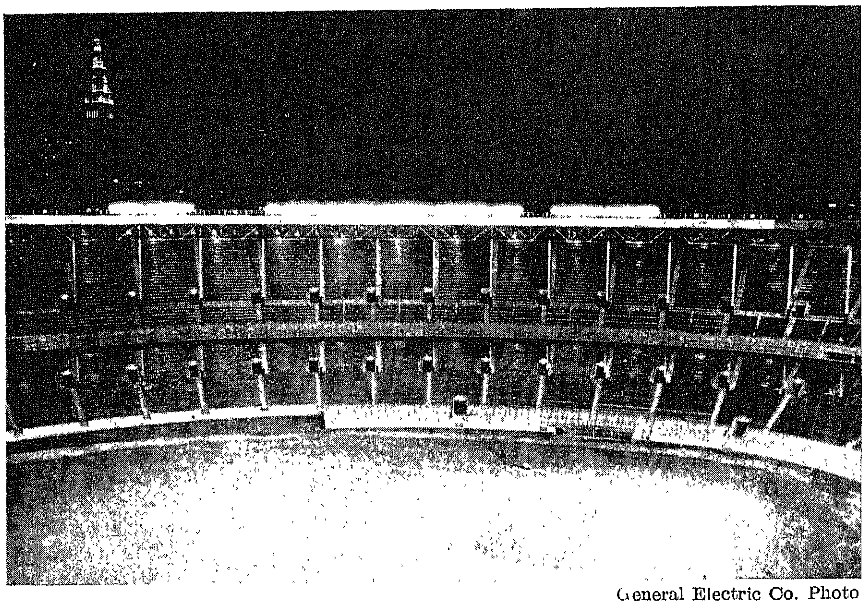
Past-President Charles F. Scott (F'25-HM'29) three-year chairman of the A. I. E. E. Lamme Medal committee and long-term active leader in Institute affairs, presided during the presentation ceremonies. Doctor Scott opened the meeting with a historical sketch covering the life of the founder Benjamin Garver Lamme, and his triplicate bequest to the A. I. E. E., to the Society for the promotion of Engineering Education and to the Ohio State University.

Doctor Scott introduced P. L. Alger, chairman of the A. I. E. E. electric machinery committee, who gave a biographical sketch outlining Doctor Foster's engineering achievements and paying him high tribute, saying, "No one has been more intimately and continuously associated with the development of large electrical machinery during its period of most rapid progress than has Dr. W. J. Foster."

Doctor Scott then called upon W. S. Lee, president of the Institute, to present the medal and certificate to Doctor Foster.

Doctor Foster in his response gave a brief outline of the history of rotating electric machines saying that while "it is possible that the art of designing rotating machines is nearing the climax I see no reason for not expecting still larger generating units. . . . However, it is probable that the outlook for real creative work now is in the line of motors rather than generators."

Cleveland's New Stadium Floodlighted



General Electric Co. Photo

CLEVELAND'S new $3,000,000 municipal stadium, said to be one of the country's best lighted sport arenas, is illuminated by 250 floodlighting projectors each equipped with a 1,000-watt incandescent lamp. These units are mounted along the stadium roof 110 ft. above the ground and arranged to give a normal average intensity of 20-ft. candles over the entire playing field with special provisions for intensities up to 50-ft. candles as required by different branches of sport. In the accompanying night view of one end of the stadium the tower of the new Union Terminal may be seen. Permanent seats are provided for 78,189 spectators.

Shall it be Price or Quality?

Because it reflects a serious condition that by no means is limited to the radio division of the field of electrical apparatus and appliances, and because electrical engineers well can afford to devote serious thought to the problems involved, the following editorial from the July 1931 issue of the McGraw-Hill publication *electronics* is reprinted herewith in full:

"The Blight of Price"

"Radio now faces a new internal competition—the bitter wrangle of price whittling—which is bound to manifest itself as a blight on every part of the industry.

"Former standards of quality are being abandoned in some quarters, in desperate efforts to get prices below competing low standards.

"Conservative factors of safety in set design and set manufacture are being wiped out, and the market is being flooded with receivers which 'just get by'—with prospects of troublesome breakdowns after a few months in the customer's hands.

"Tone quality—a requirement all important if broadcasting is to continue as a dominant musical medium—seems to have been forgotten, in the race to shave costs.

"All along the line, this blight of price is being felt, throughout the trade and industry, and in the associated fields of broadcasting and parts manufacture.

"Makers of components entering into radio sets find that their specifications and prices are being hammered down until price paralysis penetrates even the outermost fringes of parts making.

"Dealers and distributors protest that present low price units give them little on which to operate successful businesses. Broadcasters see the doom of their great new art, if poor radio reproduction is to be the standard,—rather than full fidelity of tone.

"Every group concerned deplores the price situation in which radio finds itself today.

"It is time the radio industry turned about and climbed out of this price morass. Every group is anxious to get back on good firm ground.

"Strong leadership will find an army ready to follow."

"Handbook of Oil Burning" Issued.—Information of practical value to the electrician whose work requires a knowledge of electrically operated oil burners is contained in the new "Handbook of Oil Burning" ($3.00) just published by the American Oil Burner Association, 342 Madison Avenue, New York, N. Y. Besides a thorough treatise on the part played by electricity in the operation of modern oil burning heating or power plants, the book discusses the different oil burner types and principles of construction, oil burner controls and motors, and the wiring of a house or building for an oil burner installation. A wealth of general information such as the fundamentals of heat and heat transfer, the chemistry of combustion and flame, the determination of heating capacity requirements, comparative fuel costs and like subjects is also included. Printed in pocket size for convenience, the new handbook contains 629 pages with 123 tables and 358 illustrations and charts spread over 24 chapters.

I. E. C. Plans for 1932 Paris Congress

The year 1931 represents 50 years of organized international electrical endeavor since that first convention in Paris in 1881, when the principal issue between nations whose delegates were in attendance was a decision on electrical units.

In a desire to make its 1932 congress in Paris particularly momentous the International Electrotechnical Commission has asked its United States national committee to appoint a subcommittee in charge of American participation in this congress. This special committee is now in process of organization; notice of personnel, detail of operation, etc., will be given publicity later. Until more complete plans have been perfected, all inquiries may be addressed to H. S. Osborne, secretary, United States National Committee, Room 1018, Engineering Societies Building, 33 West Thirty-Ninth Street, New York, N. Y.

Lamme Medal Award to C. A. Fieldner

The Lamme Medal award made this year at the Ohio State University was practically in duplicate; it being the first time the ceremony has taken place since the establishment of this special fund. The accumulated amount gave rise to a double presentation.

One of these medals went to C. E. Skinner, president of the Institute, (June, 1931, ELECTRICAL ENGINEERING, p. 524), and the parallel award was made, for like accomplishment—"for meritorious achievement in engineering or the technical arts"—to C. A. Fieldner, chief engineer, U. S. Bureau of Mines, Washington, D. C.

S. A. E. Meeting Discusses Novel Plans

With approximately 700 representative automotive engineers in attendance at its opening session, the summer meeting of the Society of Automotive Engineers convened at White Sulphur Springs, Va., June 14-19, "to solve problems of new designs and increase of production" in automotive industries. Fourteen technical sessions were occupied with subjects such as aircraft, automobiles, the evolution of the Diesel and other automotive engines, Diesel fuels, transportation, the investigation of detonation, the elimination of "vapor-lock," and results obtained by Bureau of Standards research.

Information on the new and unique "tear-drop" automobile body design was presented in a paper by W. T. Fishleigh, consulting engineer of Detroit, and discussed in some interesting detail. The Honorable D. S. Ingalls, Assistant Secretary of the Navy for Aeronautics flew to the convention in an autogiro to be the speaker Thursday evening, June 17, when Dr. G. W. Lewis, of the National Advisory Committee was presiding officer. A diversive program included a water carnival, field day athletics, flying, golf, tennis, archery, and a "grand ball."

Coffin Award Won by Virginia Electric.—The Chas. A. Coffin annual award to "the central station company which has done most for electrical art during the preceding year" was made in June in connection with the 1931 convention of the National Electric Light Association. This award established by the General Electric Company in honor of its founder, carries with it a check for $1,000 to be placed in the winning company's mutual benefit association. The Virginia Electric Light & Power Company received the honor for "increased efficiency of public benefit."

Rear-Mounted Automobile Engine is Predicted

Rear engine mounting for motor cars is a subject which is being seriously considered by the Society of Automotive Engineers. Placing the steering wheel in the center of an automobile and devoting most of the front half to the power plant seems absurd to Herbert Chase, a consulting engineer of New York, who pleads the case for this innovation: "Even a fairly long engine can be placed transversely at the rear of the chassis, and various cylinder arrangements are available that are not feasible for use under a normal hood in front, making the proportional length of chassis occupied by the engine much smaller than in conventional designs.

"Grouping all the mechanism at the rear gives the body designers a free hand; a streamline form becomes possible for the complete vehicle, parts such as lamps and spare tires being enclosed. Larger seating space, a better position for the driver, improved riding-qualities and a saving in weight are held out as objects to be gained by moving the engine from the front to the rear.

"Various forms and arrangements of the mechanical units are available, most of them calling for the engine, transmission and differential in a single, compact unit that is readily accessible and easily adapted for quick removal. Engine cooling and the control connections present two of the more difficult problems."

A. S. T. M. Announces New Officers and Activities

Announcement is made of the following officers of the American Society for Testing Materials for the year 1931: F. O. Clements, technical director, research laboratories, General Motors Corporation, Detroit, president; S. T. Wagner, consulting engineer, Reading Company, Philadelphia, Pa. vice-president; and A. W. Carpenter, manager, testing laboratories, B. F. Goodrich Company, Akron, Ohio, K. B. Cook, technical manager, Manville Jenckes Company, Pawtucket, R. I., J. B. Johnson, Chief, Material Branch, Material Division, U. S. Army Corps, Wright Field, Dayton, Ohio, G. C. D. Lenth, consulting engineer, Chicago, Ill., and O. L. Moore, engineer of tests, Universal Atlas Cement Company, Chicago, Ill., members of the executive committee.

The recently organized International Association for Testing Materials, (W. H. Fulweiler, United Gas Improvement Company, Philadelphia, American representative) holds its first congress September 6-12, 1931. Headquarters will be at the Swiss Federal Polytechnicum, Zurich, Switzerland, and the various countries represented by individuals and by companies will contribute to a technical program divided into four groups: (A) metals; (B) non-metallic organic materials; (C) organic materials; and (D) questions of general importance. Americans, all members of the A. S. T. M. and among them W. A. Slater, research professor of engineering materials, Lehigh University, W. A. Selvig, chemical engineer, U. S. Bureau of Mines, L. T. Work, asst. prof. chemical engineering department, Columbia University and H. F. Moore, professor of engineering materials, University of Illinois, will contribute papers the chief object of the congress being to secure international cooperation, and an exchange of views and experience in all matters incident to the testing of materials. Mr. Fulweiler may be addressed in care of his company or A. S. T. M. headquarters, 1315 Spruce Street, Philadelphia.

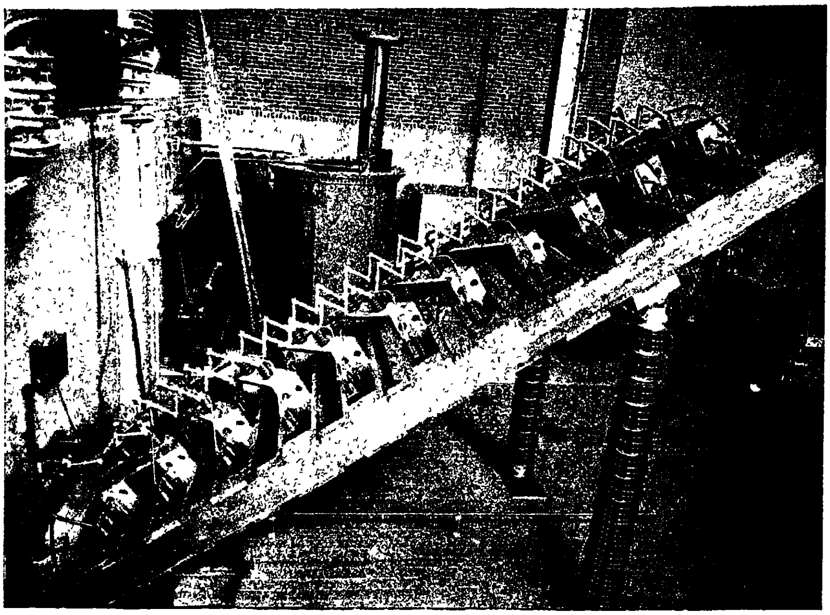
W. L. Saunders Comes to End of Active Life

William Lawrence Saunders, chairman of the board of directors of the Ingersoll-Rand Company, New York, and for most of his 75 years active in engineering and many other fields, died at Teneriffe, Canary Islands, June 25, 1931.

All his life he was ever watchful of opportunities to fill a breach or meet an emergency. As early as the year 1876 while on a newspaper in Philadelphia (perhaps an outgrowth of his having been editor-in-chief of the University of Pennsylvania Magazine, and class poet) he made two balloon ascensions to an altitude of several miles remaining up over night, an evidence of grit and initiative, as were also his courageous experiments in the development of his well-known equipment for rock drilling under water. A warm personal friend has said of him, "He wanted to be in everything, and he got there!"

He was president of his company at the time of its incorporation. During the World War, he was member and then chairman of the Naval Consulting Board, President Wilson giving personal recognition and appreciation of his work. He was past-president of United Engineering Society and of the American Manufacturers Export Association; a fellow of the American Geographical Society; member of the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, New York Chamber of Commerce, American Iron and Steel Institute, New Jersey Harbor Commission, and the National Foreign Trade Council; a director of two mining companies and president of *Compressed Air Magazine*. He was a prominent figure in the political life of the State of New Jersey and twice mayor of North Plainfield, his place of residence.

Lightning Generator at Purdue University



FOR studying lightning discharges and their effects upon electrical apparatus, this 1,000,000-volt lightning generator was placed in the engineering experiment station of Purdue University in June 1930. The 44 condensers are charged by subdividing them into eleven parallel groups of four each and applying a d-c. potential of 100-kv. through resistances of 200,000 ohms per bank. Charging potential is obtained from two 150-kv. 250-milliampere kenotrons, and can be varied by means of a full 100-per cent buck or boost regulator connected to the primary winding of the 5-kva. transformer supplying these tubes. The charging apparatus is remote-controlled from a push-button station, while discharge is initiated by a three-electrode and trigger-gap arrangement which makes possible also the synchronizing of a cathode-ray oscillograph with the discharge.

George Washington Bridge (N. Y.-N. J.) to be Well Lighted

Under an arrangement similar to that now in effect in the Holland Tunnel between New York City and New Jersey, the Public Service Electric and Gas Company (New Jersey) and United Electric Light and Power Company (New York) each will furnish half of the electric energy for illuminating the new George Washington Bridge across the Hudson River.

The new span will be lighted by 230 lamps (500-watt each) on 18-ft. standards spaced approximately 90 ft. apart on opposite sides of the roadways. Lights to be serviced by each company will be in staggered arrangement so that if one of the services is interrupted, half of the lights on the bridge still will remain lighted thus providing temporary illumination for the entire length of the roadway. Some 200 lamps (50 watt) suspended from up-stream and down-stream cables, will show these general curves so that at night aviators may avoid them. Because of the width of the roadway at the New Jersey approach, illumination of the bridge will be provided by floodlights mounted on the top of two 100-ft. ornamental towers. On the top of each of the two towers on the bridge there will be installed two Department of Commerce air beacons.

Societies' Library Reports on Service

In recent report, Harrison W. Craver, director of the Engineering Societies Library, states that during the first five months of 1931 there have been added to the library either by gift or purchase, 4,880 books and pamphlets. Of these, 3,030 have increased the main collection which now represents 66,527 titles indexed under 37,100 subjects with 434,326 cards and 135,574 classifications. The budget appropriation for 1931 is $56,653.55. Five months' service record is as follows:

Searches made	42
Articles translated	89
Books loaned to distant members	90
Members served by mail	1,561
Telephone inquiries satisfied	2,553
Number of visitors	12,255
Members served in person	18,726
Photoprints (to 2,136 persons)	21,691
Total, (books and pamphlets)	141,546

So far, the 1931 use of the library shows increase over the 40,000 engineers by whom it was used during 1930.

Dr. Karl T. Compton, president of the Massachusetts Institute of Technology was the recipient of the Rumford Medal, an award made by both the Royal Society and the American Association of Arts and Sciences "for the most important discovery and useful improvement in heat and light." Doctor Compton received it in recognition of his contributions in the field of thermionics by the study of electron emission from hot filaments, and in spectroscopics by the study of matter means of light waves.

Industrial Accident Statistics.—This 1931 edition of the booklet containing a record of injury rates in 28 American industries up to the year 1930, includes compiled from activities of electric railways, automobile production, construction, metallurgical operations and some other less technical occupations. It has just come from the press of the National Safety Council, Inc., 20 North Wacker Drive, Chicago.

Around the World with Light's Golden Jubilee.—An attractive and comprehensive "summary" by the International Committee on Light's Golden Jubilee, containing in alphabetical arrangement by name of country, some 70 pages of cuts and text illustrative of each country's share in this world-wide demonstration, has just come from the publishers. This souvenir booklet has been placed in the Engineering Societies Library, New York, that it may be of ready access to anyone caring to rehearse the pleasures and interest of this epoch-making event—"an extraordinary tribute to a great genius."

Dr. C. M. Slack, research engineer of the Westinghouse Lamp Company, by developing a glass bubble to be used as a window in the Leonard ray tube, won the $500 cash prize offered yearly by the Westinghouse company for "the most important changes either in manufacturing methods or design of a product of the company."

Standards

Graphical Symbols for Electric Traction Proposed

Pamphlet form of a standard proposed for "graphical symbols used for electric traction including railway signaling" (A. I. E. E. Std. No. 17g5) has just become available for suggestion and criticism. This report was prepared by a subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, working under the procedure of the American Standards Committee and sponsored by the Institute and four other organizations. Copies may be had without charge from H. E. Farrer, secretary, Standards Committee, A. I. E. E., 33 West 39th Street, New York, N. Y.

The report is limited to symbols for apparatus generally used for all classes of electric traction and railway signaling, for power houses, substations, transmission systems and distribution systems; electrical equipment of electrically-operated cars and locomotives; and electrical equipment and associated equipment used for railway signaling. In general, these symbols are intended for one-line diagrams of multi-phase a-c. systems, or on complete wiring diagrams of single-phase a-c. and two-wire d-c. systems. Where possible to have these symbols correspond with those in other reports and in other sections of this report, this has been done, but in some cases common agreement could not be obtained. It is hoped, however, that a period of use will bring them into complete harmony.

Engineering Foundation

Foundation Sponsors Publication Program

Initiated by a communication bearing the signatures of the presidents of the four Founder societies and the chairman of The Engineering Foundation, the latter organization has undertaken the publication of a series of articles dealing with various phases of the general subject "has man benefited from engineering progress." The first of these articles introduced by excerpts from the aforementioned communication appears on pages 641-4 of this issue of ELECTRICAL ENGINEERING.

The Foundation's stated aim in this noteworthy project is to "disseminate sound information among the millions of men and women who are vitally concerned" in the hope of "advancing the good of mankind by stimulating resourceful Americans to think their way through the passing months of maladjustment into effective action that will restore our normal state of steadily ascending happiness and freedom." To quote further:

"The Engineering Foundation has requested leaders of thought in many fields to state some of their observations of facts on the benefits which men of our times have obtained through the help of science and engineering. Their answers will be widely published with the intention of making them generally useful in these days when so many persons have had thrust upon their attention the problems of business, economics, social organization, and personal subsistence, which too many persons rarely consider seriously.

"The Engineering Foundation will welcome constructive contributions of additional information or comment from readers of the statements as they appear in newspapers and magazines."

Ambrose Swasey Gives $250,000 More

Another gift, of $250,000, from Mr. Ambrose Swasey (HM' 28) making his contributions total three-quarters of a million, has just been announced by V. N. Dorr, president of United Engineering Trustees, and H. H. Porter (M' 12) chairman of The Engineering Foundation.

At a dinner tendered by Chairman Porter at the University Club, New York, June 30, 1931, at which thirty presidents and former presidents of national engineering societies including the Engineering Trustees and The Engineering Foundation were present, together with other nationally prominent engineers, Mr. Swasey stated that in 1914 he became impressed with the thought that great and far reaching assistance might be rendered by a stimulation of research and development work in the engineering profession. Consequently he was inspired to work for the establishment of The Engineering Foundation, and now, "having a high appreciation of the very practical and helpful results already achieved and believing that the broad and well-laid plans of the Foundation promise even greater service in the future," Mr. Swasey generously makes possible the expansion of these activities by placing in the hands of the United Engineering Trustees this additional fund of $250,000 "for the furtherance of research in science and engineering or for advancement in any other manner of the profession of engineering and the good of mankind."

Mr. Swasey, now approaching 85, survives Mr. Warner in the Cleveland firm of Warner & Swasey, long famous for large telescopes, precision instruments, and machine tools. Doctor Pupin (President '25-'26) has stated that "had it not been for The Engineering Foundation it is quite possible that the National Research Council would not exist" and that therefore "several national problems which men in the united engineering societies, aided by The Engineering Foundation and guided by its ideals, can help to solve" would have had to remain perplexing obstacles to progress.

Personal

Dr. Harris T. Ryan Becomes Emeritus Professor

As of August 31, 1931, Dr. Harris J. Ryan (F'23 and past-president) retires from his long and successful career of active teaching at Stanford University, but in so doing he still retains the dual commission of emeritus professor of electrical engineering and honorary director of the Ryan Research Laboratory. This move is in accord with Stanford's established policy of relieving its professors of active class responsibilities upon the attainment of 65 years of age.

To those who have known and appreciated the diligence and attainment with which Doctor Ryan has labored for the profession, it is gratifying to learn that his plans for the future include a continuation of active research in the field of high voltage where he is looked upon as a worthy authority. For more than a decade his work has pioneered its way through obstacles in the path of electrical progression, and his realizations in connection with electrical application have eclipsed even the hopes of many men of science and the profession. In training his students for their specific work his principle has been always that any researches undertaken should be for maximum value to the engineer in the field; and in the founding (1926) of the Ryan High-Voltage Laboratory at Stanford University, reward for his untiring efforts, in the practical and consistent application of his principle was given concrete form.

His contributions to technical literature are well-known; men of such organizations as the National Academy of Science, The American Physical Society, the American Association for the advancement of Science and others of similar importance representing science, engineering, and industry, have done him homage in friendship as well as in professional relationship. Doctor Ryan's whole career exemplifies fine achievement, cooperative spirit, cordial personality, and unusual ability of execution.

R. A. Millikan (M'22) whose discoveries in the realm of physics have made of him an international figure, has been named to return the visit of Professor Einstein. Only a short time ago Doctor Millikan was introduced to his radio audience by President Hoover, who designated him as "more than a physicist—one of America's leaders in philosophic thought." Recently also he was one of six notable physicists to receive first awards from a $1,000,000 trust fund established by Gustav Oberlaender, manufacturer of Reading, Pa., "to enable mature American citizens to study in Germany" and "increase understanding and good will between the people" of the two countries.

Ralph Kelly (A'12) southwestern district manager of Westinghouse Electric & Manufacturing Company, has just announced the appointment of L. S. Washington (A'19) as manager of the company's northeastern section, and that of E. D. Stewart (A'12) as manager of the southwestern section of his district. For the past several years Mr. Washington has been syndicate representative for Westinghouse in St. Louis and a member of the St. Louis Electrical Board of Trade. Mr. Stewart's new work gives him complete charge of company activities in the Houston, Dallas, San Antonio, and El Paso offices and respective territories.

C. L. Proctor (A'08) since 1925 vice-president and general manager of the Toledo Edison Company, an office which he holds also with the Lake Shore Power Company and the Toledo and Indiana Railroad Company, is now president of the east central division of the National Electric Light Association. He already has served in its midwest and southern divisions as a member of its executive committee. The Oklahoma Utilities Association and the Kansas Utilities Association also lay claim to him in like capacity.

J. A. Darling (A'21) assistant chief system operator, Edison Electric Illuminating Company, Boston, Mass. has been made chairman of the Operators' Association of New England. In token of his extended service with the company he was the honor guest at a complimentary dinner and the recipient of a 30-year service pin and Telechron clock with Westminster and Canterbury chimes from the Company.

H. E. M. Kensit (M'08) after 15 years in the Dominion Civil Service retired August 1, 1931, to enter private practise. Mr. Kensit is a member of the Engineering Institute of Canada and of the Association of Professional Engineers of Ontario. He joined the Institute in 1908 as an Associate but immediately advanced to the grade of Member.

C. H. Champlain (A'28) for the past eight years manager of the Westinghouse works at Sharon now has been made works manager at East Pittsburgh; while A. B. **Raynders** (A'07) in addition to his present duties as works manager, East Springfield, Mass., will assume supervision of operations at the Mansfield, O.

Charles M. Burrill (A'25) who has been broadcast receiver development engineer for the R. C. A. Victor Co., Inc., Camden, N. J., has gone to Ontario, Canada, to become research engineer for the Rogers-Majestic Corporation, Ltd. Mr. Burrill is 1930-31 chairman of the I. R. E. subcommittee on high-frequency receivers.

E. T. Moore (F'21) president of the Power Control Corporation of Syracuse, N. Y., is in Mexico where he will supervise the first installation of his invention the power demand limitator in a Mexican mine at Chihuahua. Later he plans to go to Mexico City, and thence to San Francisco, Los Angeles, Seattle, Salt Lake City, and points in Arizona.

W. M. Abbott (M'22) chairman of the board of directors of the Illinois Bell Telephone Company, on May 1, 1931, at the annual meeting of the Chamber held at Atlantic City received reelection as vice-president of the Chamber of Commerce of the United States for the Northern Central Division.

Frank Thornton, Jr. (F'21) manager of residence engineering, general engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been chosen manager of the company's association activities to succeed R. W. E. Moore (M'17) recently resigned.

Frank J. Meyer (M'17) assistant to the general manager, in charge of operation, Oklahoma Gas and Electric Company, Oklahoma City, Oklahoma, now has become its vice-president in charge of operation. Mr. Meyer is chairman of the Institute's Section in Oklahoma City.

Stanley Stokes (F'29) assistant vice-president of the Union Light & Power Company, St. Louis, Mo., has been appointed consulting engineer for that company and its subsidiaries. This new office will permit him to devote his entire attention to major engineering matters.

R. W. Allen (A'23) who has been acting in the capacity of distribution engineer for the South County Public Service Company, Westerly, R. I., recently accepted like position with the New England Power Engineering and Service Corporation, Providence, R. I.

G. F. Chellis (M'16) manager of Ferranti, Inc., New York, N. Y., has severed his connections with the American organization to accept a position with the Whitehall Securities Company, London, England, where he will be associated also with the English Ferranti Company.

Harry Reid (A'22) president of the National Public Service Corporation and the National Electric Power Company, New York, N. Y., and for more than 25 years prominently identified with electric light and power industries, now becomes vice-president of the N. E. L. A.

T. H. Morgan (A'23) has resigned from the office of assistant professor of electrical engineering, Stanford University to become head of the department of electrical engineering at Worcester Polytechnic Institute, Worcester, Mass.

H. T. Edgar (M'28) for the past 32 years associated with Stone & Webster in managerial work throughout the country as a division manager, after 45 years of service in the public utility field has resigned.

W. H. Bliss (A'30) graduate assistant in electrical engineering, Michigan State College, East Lansing, Mich., and designer and constructor of the "Telomat," is now instructor in electrical engineering there.

George Brock (A'19) draftsman for the Edison Electric Appliance Company, Pomona, Calif., has received promotion to the position of cost reduction engineer for his company.

Ralph A. Watson (A'08) consulting engineer of Champaign, Ill., is now on his way to Russia as consulting engineer for Arthur McKee & Company, of Cleveland, Ohio.

W. H. Taubert (A'29) has been placed in charge of sales in the insulation division of the Corning Glass Works, and is removing from New York City to the company's home office at Corning, N. Y.

Obituary

Edward G. Acheson, (M'88 and Member for Life) chairman of the board of the Acheson Oildag Company which he himself founded, died at the home of his daughter New York City July 6, 1931, of pneumonia. As a scientist and inventor he was known internationally and was the recipient of many medals and honors both here and abroad.

He was born at Washington, Pa. in 1856 and passed his youth in the manner of the average country boy, with no particular inclination toward the classics but most pronounced fondness for mathematics. In his first position as time keeper at a blast furnace in Monticello, Pa., he was permitted considerable time for mechanical pursuits, and at the age of seventeen was granted his first U. S. patent on a rock-boring machine. The financial depression of 1874 closed the blast-furnace and Mr. Acheson was compelled to engage in non-technical labor until 1877 when he secured a position with the Alleghany Valley Railroad, which ultimately led to the work of tank gager in the Bradford oil fields. Irregularities of construction at that time greatly complicated capacity calculation, so Acheson promptly set about constructing a set of tables whereby the content of any tank could readily be determined. His efforts however did not meet with the approval of a superior whose business it was to calculate these capacities, and Acheson was dismissed. He entered the service of the Pittsburgh Southern Railroad as assistant to a surveying party; advances in electricity stirred his imagination and in a desire to become actively engaged in what was then a new industry, in 1880 he sought and obtained a position as draftsman with Thomas Edison at Menlo Park. Fortunately for him he was not confined closely to the drafting table but allowed to indulge his inventive genius and in 1881 he produced a graphite loop filament for the preparation of which he received the prize of $100 offered by Mr. Edison. Under date of January 8, 1889 he presented his first paper before the A. I. E. E. on the subject of *Lightning Arresters and a Photographic Study of Self-Induction.* Perhaps one of his greatest contributions to commercial science was his discovery of a new chemical compound produced electrically at the power plant of the Monongahela Electric Light Company which he founded in 1890. While working on the reduction of iron ore, he noticed that clay objects placed within the furnace became impregnated with carbon and as a result, much harder. Experimenting with similar clay-carbon mixtures, he produced a new chemical compound, silicon carbide, commercially known as carborundum. As it was hard enough to surface a diamond, it found ready market with jewelers and the Westinghouse company promptly placed a $7,000 order for 60,000 grinding wheels.

William F. Smith (M'27) assistant superintendent of power, Pacific Electric Railway Company, Los Angeles, Calif., passed away at his home in that city June 14, 1931. He was a native of the state of Missouri (1875) and was educated in the Santa Cruz high school and the correspondence school of Scranton, Pa. From 1894 to 1897 he was occupied with construction and operating work for the Santa Cruz Electric Railway; the next several years were engaged in construction and car house work. He was in charge of the installation of multiple-unit equipment of the North Shore Electric, Sausilito, Calif. and also reconstructed some operations of the Power Development Company, Bakersfield, Calif.; in fact most of his work has been construction and remodeling, including the Central Station of the Los Angeles Railway Company and all high-voltage work in all the stations of the Pacific Electric Railway. His Membership in the Institute dates from 1905, when he joined as an Associate.

Truman P. Gaylord (M'21) acting vice-president of Westinghouse Electric & Mfg. Company, with which he had been connected since 1900, died suddenly of heart disease at the home of his mother in Shelby, Mich., the place of his birth February 15, 1871. As a preparatory school for his later training, he attended the Allen Academy of Chicago, later to enter the University of Michigan, from which he was graduated with a degree in electrical engineering. In 1895 he secured a second degree from Armour Institute of Technology at which he held an associate professorship in electrical engineering 1894-98. The World's Fair at Chicago was starting and Mr. Gaylord engaged with the Fair company as engineer of underground construction, continuing in that capacity until 1893. From 1898 to 1899 he was engineer for the Chicago Edison Company, and July 1899 took his first position with the Westinghouse Electric Company. In 1902 he was appointed its district manager with offices in Chicago, a position which he occupied until he became acting vice-president, August 1914. By the board of directors of the Pittsburgh Chamber of Commerce he was recently elected president; also he was director and member of the executive committee of the Pennsylvania State Chamber of Commerce, and member of the United States Chamber of Commerce, the Duquesne Club of Pittsburgh, and the Pittsburgh Athletic Club. He was in charge of the radio division of the Westinghouse Electric & Mfg. Company, remained active and was apparently in good health up to the day of his death. He joined the Institute in 1902 as Associate.

H. G. Specht (M'23) consulting engineer for Westinghouse Elec. & Mfg. Company, Springfield, Mass., died May 17, 1931. He was a native of Farmsen-Hamburg, Germany (1876) and as a young man served several apprenticeships with German manufacturing interests, among them the Machine Company of Grotkast & Kespohl at Wandsbeck and the Electric Mfg. Company of Klamberg at Hamburg. During the year 1896-97 he was in military service in the Engineering Corps at Berlin after which he studied mechanical and electrical engineering for two years at the university in Braunsweig, Germany. His next work was one of design for steamship and dredging machines in the city engineering department at Hamburg. Continuing his electrical engineering study, in January 1902 he graduated from the University in Karlsruhe with his E. E. degree. His work with Westinghouse dates from 1903, when he came to America and joined the East Pittsburgh office, where his work was chiefly test and the development of test curves in the dynamo test department. By 1905 he was designing special induction motors of all sizes and types. His paper *The Synchronous-Repulsion Motor—A Special Development for the Photophone* formed an integral part of the program at the North Eastern District meeting of the A. I. E. E. held at Springfield, Mass., May 7-10, 1930. His membership in the Institute was endorsed by such men as President C. E. Skinner, B. G. Lamme, C. F. Scott, P. M. Lincoln, and B. A. Behrend, all outstanding in the history of the Institute.

C. M. Rosewell (M'21) electrical engineer, Western Electric Company New York, N. Y., died at the Fairmont Private Hospital, Jersey City, N. J. June 2, 1931. He was 47 years of age and a graduate of the State University of Kentucky, from which he received his degrees in both mechanical and electrical engineering respectively 1908 and 1911. During the summer of 1908 he was operating engineer in charge of the plant of the Jackson Electric & Hydraulic Mfg. Company, Jackson, Ky.; the following year he spent in the test department of the Bullock Electric Company, Cincinnati, Ohio. From 1909 to 1913 he continued his test department work with the General Electric Company in Schenectady, advancing each year, from the test department to d-c. motor and generator design engineering, to central station engineering in the lighting department, to central station engineering and commercial engineering. In 1918 he was appointed engineer of the Appalachian Power Company in charge of practically all of the company's engineering. Bespeaking energy and ambition, while he was regularly busy during the week with other duties he engaged for special Saturday night service as night operator of the General Electric's power house switchboard; he also substituted for the superintendent at the Appalachian Power Company when that executive was off duty. He joined the Institute in 1919 as an Associate but in 1921 was transferred to the grade of full Member.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Bunce, Lewis I., Rocky Hill, Conn.

Cartwright, Kenneth C., Haig Hotel Annex, 2548 Prospect St., Cleveland, Ohio.

Cole, Will G., Box 222, Westwood, Calif.

Corrivbax, F. M., General Electric Co., Schenectady, N. Y.

Deacon, L. O., 6 Ailsa Ave., East Malvern, Melbourne, Australia.

Haggerty, John J., 2849-33rd St., Astoria, N. Y.

McLean, James S., 190 Old Army Road, Scarsdale, N. Y.

Nuber, Frank J., 3831 Rokeby St., Chicago Ill.

O'Shea, V., Jr., 115 Broadway, New York, N. Y.

Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.

Prudham, W. M., 100 Biddle St., Wilkinsburg, Pa.

Sullivan, John E., 6320 Kenmore Ave., Chicago, Ill.

Tung, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Past Section Meetings

Portland Section Meets With O. S. C. Branch

The annual spring joint meeting of the Portland Section and the Oregon State College Branch was held at the college May 23, 1931; attendance 100.

Following a dinner, four technical papers were presented by students:

A Bridge Method of Testing Welds, by J. R. Batcheller.

Weld Strength as Indicated by Relative Conductivity, by Glen Barnett.

Influence of Preservatives on Dielectric Strength of Wood, by C. B. Parsons and M. H. Tiplon.

Moisture Content of Wood and Its Relation to Electric Permittivity, by O. E. Boucher and Hamilton Howell.

Cleveland

Annual dinner meeting at which W. S. Lee, president A. I. E. E., and consulting engineer and president, W. S. Lee Engineering Corporation, Charlotte, N. C., spoke on Doing a Common Thing in an Uncommon Way. Election of officers: G. A. Kositzky, chairman; F. E. Snell, secretary. May 21. Attendance 77.

Columbus

Rhythmic Ramblings through Our National Parks, by Dean Alfred Vivian, Ohio State University. Election of officers: W. L. Everitt, chairman; Roy Mallory, secretary-treasurer. May 28. Attendance 15.

Detroit-Ann Arbor

Golf tournament followed by dinner, Election of officers: Joseph J. Shoemaker. chairman; Raymond Foulkrod, vice-chairman; Oscar E. Hauser, secretary-treasurer. June 20. Attendance 43.

Kansas City

Annual banquet. The Inductive Relations between Power and Telephone Lines, by A. T. Campbell and C. C. Yates, both of the Southwestern Bell Telephone Company. Election of officers: George Fiske, chairman; R. M. Ryan, secretary-treasurer. May 29. Attendance 93.

Madison

Machines, by Prof. C. M. Jansky, University of Wisconsin. Demonstrations at the electrical laboratories followed this talk. Election of officers: Norman H. Blume, chairman; G. F. Tracy, secretary-treasurer. June 3. Attendance 44.

Toledo

Institute Affairs and Activities, by E. C. Stone, The Philadelphia Company, and vice-president, District No. 2, A. I. E. E. Election of officers: J. A. Dinwiddie, chairman; Max Neuber, secretary-treasurer. June 12. Attendance 34.

Urbana

Audible Light, by John B. Taylor, General Electric Company, Schenectady, N. Y. May 26. Attendance 200.

Vancouver

Dinner. Election of officers: G. R. Wright, chairman; C. Arnott, secretary. June 8. Attendance 25.

Worcester

Inspection trip through the Tewksbury substation of the New England Power Association. June 13. Attendance 20.

Past Branch Meetings

University of Colorado

TRANSMISSION CONSIDERATIONS IN CHAIN BROADCASTING, by R. C. Giese, American Tel. & Tel. Company., Denver, Col. May 20. Attendance 45.

Election of officers: Fred W. Cooper, chairman; Sidney Larson, vice-chairman; Wendell C. Spear, secretary, John F. Drescher, treasurer. May 28. Attendance 45.

College of the City of New York

Election of officers: Alexander Rosenberg, chairman; Robert G. Herzog, vice-chairman; I. E. Lawlor, secretary; L. Milstein, treasurer. May 28. Attendance 18.

Lewis Institute

Inspection trip through the Chicago office of the Western Union Telegraph Company. June 12. Attendance 18.

Southern Methodist University

Election of officers: J. V. Melton, president; M. P. Jones, vice-president; Porter Lindsley, secretary-treasurer. June 2. Attendance 8.

Washington State College

Election of officers: D. H. Olney, president; Howard Stingle, vice-president; G. C. O'Brien, secretary; G. Bliesner, treasurer. May 21. Attendance 17.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ELECTRICAL ENGINEER, 1931, single, 22, available immediately. Desires position in any electrical line with opportunity for advancement. Salary moderate. Has had some experience in public address systems. Location preferred, New York vicinity, but will consider others. C-9432.

GRADUATE ELECTRICAL ENGINEER, 22, single, B. S. in E. E., 1931. One and three-fourth years of practical experience with leading elevator company. Desires position with manufacturing or utility company. Location optional. Excellent references. C-9474.

GRADUATE ELECTRICAL ENGINEER, 1930, single, six months on Westinghouse engineering course covering tests on switchboards, circuit breakers, regulators, motors, generators, etc. Nine months supervising telephone conduit and cable plant construction and telephone cable testing. Excellent physical condition. Desires permanent position with a good future. Location, immaterial. C-9158.

SALES EXECUTIVE ENGINEER, electrical and mechanical training. Seven years' sales experience in bearing field, three years' sales engineering in application of bearings to electrical, mechanical, and automotive fields, four years' in sales management, promotion, and distribution. Would like opportunity to develop or direct sales. C-5431.

PYROMETER ENGINEER, 25, christian, single. Graduate E. E., extension course of Columbia University. Five years' experience as field engineer for well-known manufacturer of industrial instruments. Experienced in construction, application, and selling of pyrometers and automatic valves. C-8647.

GRAUDATE ELECTRICAL ENGINEER, 24, single, B. S. in E. E.; midwest university. One year of G. E. Test. Will consider position offering engineering experience. Location immaterial. Available immediately. C-9451.

GRADUATE ENGINEER, executive and consulting. Degrees E. E. and M. S. in engineering. Licensed professional engineer, New York State; 25 years' electrical-mechanical experience, design, operation, maintenance of power plants, industrial plants, modern production and plant operation. Combustion and heating, air cooled gasoline motors, heat transmission. Available now. B-8170.

GRADUATE ELECTRICAL ENGINEER. B. S. in E. E., 1931, intends to study for M. S. degree at night; 21, single. Desires position in any electrical engineering field including radio or vacuum-tube work. Available at once. Location, New York preferred but not essential. C-9467.

ELECTRICAL ENGINEER, graduate A. I. T., 24, married; eighteen months large utility company previous to college; three summer vacations as laboratory technician for radio condenser manufacturer; one year in electrical maintenance for self. Excellent references. Will accept minimum living salary with reliable concern. Go anywhere except Russia. C-8668,

EXECUTIVE AND GRADUATE MECHANICAL-ELECTRICAL ENGINEER; twelve years' experience in public utility, industrial, and marine fields. Specialized in plant management, economic studies, organization, and power plant design and operation. During the last four years supervised the expenditure of $10,000,000 for public works projects. C-9416.

ELECTRICAL ENGINEER, technical college graduate, 35. Ten to twelve years' mechanical and electrical experience in power plants, substations, and transmission and distribution systems. Work includes G. E. Test and public utility engineering and operation. Desires position on operating staff of power company. Location, not particular. B-9782.

GRADUATE ELECTRICAL MECHANICAL ENGINEER, University Budapest, Hungary; 41, American citizen. Research and development engineer with largest electric companies along manufacturing and insulating electric conductors. Expert knowledge of sound recording. Besides English, speaks German, French, Italian, Spanish, Hungarian. Desires position where also linguistic knowledge useful. Location preferred, California. C-2505.

1931 TECHNICAL GRADUATE of midwestern college, B. S. in E. E. 24, single. One year student engineer on G. E. test. References furnished. Available on two weeks' notice. C-9497.

ENGINEER EXECUTIVE, B. S. degree. twenty years' experience in engineering, contracting, and purchasing. Desires permanent connection with large industrial company or as a local representative. Location, New York City. B-5050.

TELEPHONE ENGINEER, married, 38; eleven years' experience, installation, building, equipment, and traffic engineering. Specialist on automatic equipment problems. Experience covers all types of telephone equipment. In addition to English speaks Scandinavian languages, German, and Spanish. Location immaterial. C-9532.

MECHANICAL ELECTRICAL ENGINEER for mines, or plant engineer for steel mill or allied industry; 42 years old, technical graduate, twenty years' experience. B-8653.

TELEPHONE ENGINEER, 38, married, university graduate, Lieut.-Col.-Officers' Reserve Corps; eleven years Bell System equipment engineering, five years' varied experience in Philippines and Orient. Consider anything offering opportunity for advancement. Specially qualified in planning and supervising economical and efficient provision of customers' telephone facilities. B-9568.

ELECTRICAL ENGINEER, E. E. degree, 36, single, desires position with public utility or engineering concern requiring executive ability and an analytical mind. Fourteen years' experience covering engineering, design, and valuation of power plants, substations, transmission and distribution systems. Available immediately. Location preferred, East. C-9570.

WIRE AND CABLE SALES ENGINEER, graduate electrical engineer who has specialized in electrical wire and cable engineering. Fifteen years represented public utilities and consulting engineers writing specifications, supervising manufacture, expediting, inspecting at manufacturer's plants, supervising installations. Experienced cable engineer for technical sales department of wire and cable manufacturer. B-3625.

GRADUATE ELECTRICAL ENGINEER, B. E. E. degree 1930, 24, single. Eight months on Westinghouse course. Assignments covered motor apparatus testing and refrigeration development work. Desires position with manufacturing concern or public utility. Working knowledge of Spanish. Initial salary and location secondary to opportunity. Reference. Available on short notice. C-9428.

GRADUATE ELECTRICAL ENGINEER, 23, B. S. in E. E. 1929, M. S. in E. E. 1931 from Massachusetts Institute of Technology. General Electric Test experience. Experienced in the design of motors and generators. Available on short notice. Location immaterial. C-9559.

GRADUATE ELECTRICAL ENGINEER, 27, single. Seven years' experience in supervising and laying out of electrical construction work in various industrial plants and buildings. Desires position as superintendent or electrical engineer with contracting or industrial firm or municipality. Available at once. C-9553.

ELECTRICAL-MECHANICAL ENGINEER, 39, married. G. E. student course. Eighteen years' experience sequence-motor-control systems, industrial engineering, sales, patents, investigations and reports, machinery development. Prefers connection as industrial consultant or as sales engineer. C-9552.

GRADUATE of five-year cooperative school, 22, single, B. S. in E. E. in 1931. Eighteen months' experience in the installation and engineering department of a public utility. Desires a position in any electrical line with future and an opportunity for advancement. Available at once. Location immaterial. C-9545.

ELECTRICAL ENGINEER, graduate German technical institute, 31, single. Two and one-half years with German railroad camp in maintenance of rolling stock, two years' practical experience in repair work on freight and passenger cars with American railroad camp and two years electrical inspector. Desires position with railroad camp. C-9519.

ELECTRICAL ENGINEERING GRADUATE desires position as junior engineer with public utilities concern in power plant operations or as junior engineer with construction company specializing in power plant and transmission line construction. Has had two years' experience in power plant construction and operation. C-9406.

ELECTRICAL - MECHANICAL ENGINEER, 31, married, five years' experience with American concern telephone equipment sales in United States and South America, two and a half years radio, movietone, amplifying equipment sales and installations as branch manager in Central America for European manufacturer. Speaks and writes five languages fluently. References. Available immediately. C-9558.

GRADUATE of five-year cooperative school in electrical engineering, 24, speaks Spanish and English fluently, one-year study of production methods and five years' of street railway experience, desires position in any state or nation. Location immaterial. C-9002.

ENGINEERING GRADUATE, 39 years old. Broad experience in design, construction, and operation along both electrical and mechanical lines. Willing to go to any location. Excellent references. B-5471.

ELECTRICAL ENGINEER graduated 1928, 27, married. Has civil engineering and over two years' Westinghouse test course experience. Location immaterial. Now employed by manufacturing corporation. Desires position with a future. C-9568.

ELECTRICAL ENGINEER, 1931 graduate B. S. degree in E. E. from the University of Illinois, 23, single, American. Six months' experience in the engineering department of Illinois Bell Telephone Company. Some experience Thyratron tubes, photoelectric cells. Desires position engineering company, consulting engineers. Location, anywhere in United States, Canada. C-9582.

ELECTRICAL ENGINEER, B. S. and E. E. degrees. Nine years' experience in development and production of static condensers for radio, ignition, and power-factor applications. Some work with X-ray and power-amplifier tubes and associated apparatus. B-9250.

ERECTING ENGINEER, 46, of broad experience in power plant construction, maintenance, and operation. Exceptional ability in the erection and wiring of switchboards, power plant auxiliaries, oil circuit breakers, and high-voltage outdoor substations. Available immediately. C-8702.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with eight years' experience in industrial plant construction and maintenance; railway electrification; power plant design, estimating, and construction. Supervisory experience on construction and costs with contractor. Desires position with utility, manufacturer, or contractor, where ability to handle labor and produce results is a prerequisite. C-4428.

ELECTRICAL ENGINEER, B. S. in E. E., 1927, single, 20 months' experience in design and testing of fractional-hp. motors; two years' manufacturing experience. Familiar with a-c. and d-c. motor and control application. Desires electrical engineering work. Location, immaterial. C-9168.

TECHNICAL GRADUATE, 31, married, eleven years' experience on steam and hydroelectric systems as operator and system operator. Desires position as load dispatcher or system operator. Location, immaterial, but West Coast preferred. C-7267.

INTERNATIONAL OR DOMESTIC BUSINESS, university graduate, 31, thoroughly trained and experienced, seven years' engineering and business United States and abroad; export, power system planning, developments, reports, estimating, organizing; foreign languages, German, Spanish, some French. Desires connecting holding company or trade; will consider representing concern abroad. Available short notice. Personal interview desired. C-3534.

ELECTRICAL ENGINEER, university graduate, 36, married. Background of eight years' experience electrical testing in field and laboratory, also in erecting equipment. Additional three and one-half years' experience in testing and manufacture of radio tubes. Desires position with manufacturer or laboratory. Location preferred Metropolitan New York. Available now. B-8817.

ELECTRICAL-MECHANICAL ENGINEER. Executive. Twenty-three years' diversified experience as an engineer and executive in industrial plant equipment and operation. Particularly successful in present connection along lines of mechanical plant improvement and in obtaining employee cooperation through personnel training. Can refer freely to each connection held. C-7839.

GRADUATE ELECTRICAL ENGINEER, 31, single, eight years' experience, design, and construction of transmission lines, voltages up to and including 220 kv., outdoor and indoor high-voltage substation and distribution networks. Desires position in engineering or construction department of large utility or holding company. Location immaterial. C-3564.

GRADUATE ELECTRICAL ENGINEER, University of Wisconsin, 32, single. Three years' Westinghouse Test. Seven years' supervision, power plant and transmission line construction. Eight years engineer inspector, purchasing, writing specifications, and expediting. Desires position with advancement and opportunities. Location, immaterial. Available August. B-9661.

RELAY ENGINEER, university graduate, ten years' practical experience, thoroughly familiar with all relay applications and testing, short-circuit studies, stability calculations, and all problems connected with system disturbances. Moderate salary. Available at once. C-9291.

GRADUATE ELECTRICAL ENGINEER, 1930, single. One year's experience in test, design, and development of small fractional- and integral-hp. motors. Previous experience with public utilities. Now employed. Position must be permanent and promise a good future. Location a secondary factor. C-9590.

ELECTRICAL ENGINEER, college graduate, married, five years' electrical apparatus design, fifteen years supervisor, high-voltage overhead transmission and distribution lines, substations, estimating design and construction, test field experience. Nine years' practical machine shop. Desires responsible position. C-9257.

ELECTRICAL ENGINEER, 21, single, B. S. degree in E. E., Texas A. & M. College 1931, holder of government broadcast class operator's license. Two years' experience in radio work. Desires position in radio or telephone industries. Available at once. Will go anywhere. C-9588.

ELECTRICAL ENGINEER, 23, single, graduate of five-year cooperative course. Did electrical construction work during course. Desires position with power company, engineering, or contracting firm. Location immaterial; Midwest preferred. Available immediately. C-9586.

1928 GRADUATE ELECTRICAL ENGINEER of recognized university, 26, single. Wishes employment where the following engineering experience may be used to advantage. One year power company test experience, 20 months as special apprentice on large electrified railroad, six months' radio and telephone experience. C-9112.

GRADUATE ENGINEER, B. S. in E. E. from Northern college of cooperative type; 23, single; cooperative experience; six months' production engineering in radio division of Westinghouse; six months power, local cabling drafting, including student course Western Electric; one year student engineer at Weston Electric Instrument Company; excellent references; location immaterial; available two weeks' notice. C-9599.

ELECTRICAL DRAFTSMAN, DESIGNER, five years' experience, supervisory control, wiring diagrams, plant, pole-type metering equipment, building, factory lighting, power plant layout including contracts sales, etc. Experience covers fifteen years wireless telegrapher, a-c. and d-c. motors, generators winding, shop test, repair man for all electrical equipment, lineman, meterman, switchboard repair man, power plant electrician. B-8984.

EXECUTIVE ENGINEER, 31, unmarried, graduate of outstanding engineering institution. One year of postgraduate study and teaching with record in executive capacity. Experienced on communication engineering, telephone, telegraph, radio, sound, television, etc. Speaks several foreign languages. Location, immaterial. Available immediately. C-696.

ENGINEER, Stevens graduate, one and one-half years G. E. Test, with broad knowledge of transmission operation gained during five years with public utility operating in the foreign field, seeks new connection, either domestic or foreign. Would be valuable for the staff of general superintendent being mechanical engineer with electrical experience. C-9177.

GRADUATE ELECTRICAL ENGINEER, 25; two years' experience in power system operation, system planning and development; also experience in distribution and transmission engineering. Desires position in any location with public utility, or in any electrical line offering a future. Available upon short notice. References. C-9281.

ELECTRICAL ENGINEER, 23, single, graduate Georgia School of Technology B. S. degree in E. E., Cooperative Plan 1930; five years' experience railroad shops all departments during cooperative course; one year's experience electrical utility, all branches. Desires position with utility or manufacturing concern. Prefers Southeast. C-9292.

ELECTRICAL ENGINEER, 22, single. E. E. degree, 1929; M. S. in E. E. from M. I. T., 1931; twenty months G. E. Test course. Desires position involving electric design and development. Location preferred, East. Available immediately. C-9462.

GRADUATE ELECTRICAL ENGINEER, 31, married, with seven and one-half years' experience including: 2½ years as engineer with manufacturer's service shop, two years university instructor, two years responsible position in manufacturer's engineering department and one year as electrician on station construction. Desires position with manufacturer, industrial concern, public utility. Available upon short notice. C-1073.

SECRETARY ENGINEER, as assistant to major executive or for promoting publicity with progressive manufacturing r railway industry. Good correspondent. Alert, industrious, reliable, courtous, pleasing, yet forceful personality. Holds B. S. and E. E. degrees from leading institution. Two years' graduate work engineering, business administration. Six years' experience research, development and testing. C-930.

ELECTRICAL ENGINEER, recent graduate, 23, E. E. at Rensselaer Polytechnic Institute; desires engineering work with opportunity for advancement; would like work in communication engineering or radio-tube engineering fields. Location, New York City. C-9605.

Instructors

M. I. T. GRADUATE ELECTRICAL ENGINEER, 35, married. Six years' industrial and teaching experience in electrical engineering. Several years' private research and development work on own initiative. Good ability, integrity, and personality. Desires university teaching position for life work. Location preferred, Middle West or South. C-2826.

PROFESSOR OF ELECTRICAL ENGINEERING, 40, six years' successful experience teaching practically all branches electrical engineering, state school. Considerable experience power, telephone work. One year switchboard engineering department of Westinghouse. B. S. in E. E. and E. E. degrees. Preferred location Rocky Mountains, Pacific Coast States. Available school year 1931-1932. C-5021.

PHYSICIST, middle-aged, experienced in industrial research, supervision of research, executive work and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent American universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available upon short notice. C-7900.

SUPERINTENDENT OF DISTRIBUTION, 43, married, electrical and industrial management. Twenty years' electric utility operating experience in engineering, construction, operation, maintenance of distributing and transmission lines, substations, first-aid, and educational work. Has sufficient public utility operating experience to qualify for position of superintendent. Demonstrated record of executive ability. C-8411.

GRADUATE ELECTRICAL ENGINEER, 25, obtaining Master's degree in June, 1931, desires position as assistant professor or instructor in electrical engineering or as research engineer. Four summers' employment with large utility company. Two years' teaching experience. Has had experience with development of remote-control apparatus. Location, United States. C-8994.

GRADUATE ELECTRICAL ENGINEER, 24, two years' manufacturing experience. Desires position on university staff with opportunity to work on Master's degree. Available September. C-9157.

GRADUATE ELECTRICAL ENGINEER, 23, B. S., M. S. in E. E., desires position, instructor in engineering department of college, university. Has fundamental, practical knowledge d-c., a-c. circuits and machines. Can teach engineering mathematics, physics. Has had some experience teaching, two years research work obtaining degrees. Location, anywhere in United States. C-9214.

ELECTRICAL ENGINEER, 1931 graduate of Colorado University, desires position as junior engineer, sales engineer, or instructor in mathematics or electrical engineering subjects. Has had eighteen months' practical work in electrical service and repair of power equipment prior to college. Location, Southern or Western United States. C-9241.

JUNIOR ENGINEER, 1930 graduate, B. S. degree in E. E., associate member of Sigma XI. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

ELECTRICAL ENGINEER, 28, A. B. E. E. 1926. Two years as emergency man, one year as engineering assistant with a New

York power company. Four years with a telephone company making studies of equipment and operating conditions and on service maintenance. Two years teaching mathematics in evening classes. References. C-9308.

ELECTRICAL ENGINEER, 1930 graduate, 22, single. One year on the Westinghouse student course. Desires position as instructor in electrical engineering. Available school year 1931-1932. References. Location, immaterial. C-9311.

ELECTRICAL ENGINEER, B. S. degree, married, with about fifteen years' successful experience in the design and construction of transmission and distribution lines. Some teaching experience. Employed at present. Desires position as instructor in electrical engineering subjects or physics and mathematics. Excellent references. Location preferred, Middle West or West. C-9339.

ELECTRICAL ENGINEER, 30, married. A. B. '22; B. S. in E. E. '24. (Harvard.) G. E. Test, transformer design, development and technical writing; experience in factory planning, has taught evening classes. Speaks German. Location preferred, East. C-9402.

ELECTRICAL ENGINEER, 1931 graduate from a southern technical institute, desires part or full time position as instructor in mathematics or electrical engineering, with the privilege of carrying graduate work. C-9415.

TEACHER OF ELECTRICAL ENGINEERING, 37, marrried. Thirteen years' teaching experience, many summers spent in practical work. B. S. in E. E. and E. E. degrees. Taught all E. E. subjects, as well as physics, electric thermodynamics, descriptive geometry, mechanical drawing. Sixteen months' general management large college radio station. Available immediately. C-9445.

ELECTRICAL-MECHANICAL ENGINEER, 1931 graduate with experience in central-station equipment testing. Desires position teaching in capacity of instructor or as research engineer to continue with education leading to Master's degree. C-9461.

ELECTRICAL ENGINEER, 22, single. E. E. degree, 1929. M. S. in E. E. from M. I. T., 1931. Twenty months', G. E. Test. Desires position involving electric design and development or as instructor in E. E. Location preferred, East. Available immediately. C-9462.

RECENT COLLEGE GRADUATE, B. S. in E. E., 22, single. Desires position with electrical concern or as instructor in mathematics and electrical engineering. Some maintenance experience. Location preferred, East. C-9406.

INSTRUCTOR, electrical engineer, 31, with nine years' experience with utilities, contractor, consulting engineer, and manufacturers, wishes position as instructor for electrical and mechanical engineering or drafting, mechanics, etc., in trade schools, high schools; speaks and writes German and French. Good references. C-4758.

ELECTRICAL ENGINEER, graduate University of Illinois, 1926. Two years' experience with Westinghouse Elec. & Mfg. Company, two and a half years with public utility in planning division. Available immediately. C-9381.

GRADUATE ELECTRICAL ENGINEER, Lehigh University, 1930, married, 25, ten months' engineering graduate student at Westinghouse, and 22 summer months with National Tube Company. Desires position with public utility of manufacturing company where analytical and research ability is prime prerequisite. Available upon two weeks' notice. Location, East or Middlewest. C-9395.

ELECTRICAL ENGINEER, graduate 1931, single. Three years' cooperative experience in public utility maintenance work. Four summers' experience in ice-cream industry. Desires opening offering steady work and possibility of advancement. Location and type of work secondary. Available at once. C-9418.

GRADUATE ENGINEER, B. S. in E. E., 1928, 25, single. Fifteen months' G. E. Test course, including six months in vacuum-tube-department. Sixteen months' development engineering of electrical aircraft instruments, control devices, and naval ordinance control. Also some testing laboratory experience. Available at once. Location preferred, East. C-9483.

MECHANICAL-ELECTRICAL ENGINEER, B. in M. E. and E. E. and Master degree in E. E. General Electric Test. Fifteen years' broad experience teaching, research, development, designing, and manufacturing plant management. Position desired teaching mechanical, electrical, or industrial engineering subjects; or part time teaching and management of university plant. Location, immaterial. C-4440.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E. 1929, single, 24. Twenty-one months' Westinghouse Test on rotating machinery and control apparatus. One year of advanced physics at Carnegie Tech. night school. Desires position as instructor in engineering subjects. Eastern location preferred. C-8966.

ELECTRICAL ENGINEER, B. S. in 1929 from M. I. T. Desires connection to teach engineering subjects. Practical experience in the paper-making and insulated-wire business as an industrial engineer. Able to handle men. Locate anywhere. C-9331.

GRADUATE ELECTRICAL ENGINEER, 24, B. S. in E. E. Knowledge of design, construction of indicating instruments; also knowledge of electron tube. Two year cooperative course with Weston Electrical Instrument Corporation. (32 departments including shop, office, and engineering work.) Three years' industrial work before college. Available immediately. Location, United States, Canada. C-9585.

ASSISTANT PROFESSOR INSTRUCTOR, 39, Cornell graduate, two and one-half years' teaching experience; will bring to the faculty first-hand knowledge of the latest practise in industrial work. Thoroughly familiar with practical requirements for design and installation of mechanical and electrical equipment for industrial plants, power stations, and boiler houses. A-3702.

1929 GRADUATE ELECTRICAL ENGINEER, 25, single. Fourteen months G. E. Test course including thorough experience with illuminating equipment. Also experienced in electrical maintenance, construction in manufacturing plant. Desires electrical, illuminating engineering position with future manufacturing utility company, or teaching position. Prefers Middle Western or Eastern location. Available at once. C-9560.

ELECTRICAL ENGINEER, M. I. T. graduate, with practical experience in design, construction and teaching, author of reference books in electrical and mechanical engineering, is open for teaching position. Well qualified to take charge of engineering and general courses such as mathematics, physics, drawing practical electricity, etc., in vocational and preparatory schools. B-4022.

ELECTRICAL ENGINEER, with Master's degree, desires position of professor of E. E. at a progressive university. Age 34, married. Five years with large electrical manufacturer, three years teaching electrical engineering and four years electrical engineer of an electric utility company. Available upon reasonable notice. C-1118.

RESEARCH AND DESIGN OR INSTRUCTOR, transportation field, manufacturer operating company or technical school. Five years' experience Westinghouse Electric design, manufacture and installation of control apparatus for electric cars and trolley coaches, and research and development on transportation problems. Graduate, University of Wisconsin, 1926. Age 29, single, Protestant. C-9475.

GRADUATE ELECTRICAL ENGINEER, western university, age 26. Two years with public utility company, one year's experience assistant instructor in large university in E. E. department. Operating experience with electric railroad and two years' experience in engineering professional photography. Wishes location in engineering or teaching fields. Excellent references available. Location immaterial. C-9525.

ELECTRICAL ENGINEER, B. S. degree in E. E. 1925. Two years' experience switchboard design, two years' industrial control, two years' teaching experience. Natural talent for teaching. Desires teaching position in engineering college. Location preferred, Middle West or West. C-9577.

GRADUATE ELECTRICAL ENGINEER, class 1929, age 26, single, nine months on Westinghouse graduate student course, thirteen months on transformer design. Desires position in engineering department of public utility or instructor of electrical engineering and mathematics. Location, Middle West or East. Available upon short notice. C-9549.

ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING, three years' research training and advanced study. Two years' teaching experience. Background of American and foreign utility work. Research and patents in high voltage insulation. Specialties, hydroelectric generation, transmission, radio and communication theory, transients. Best references regarding health, personality, and teaching ability. Location, immaterial. C-9813.

ELECTRICAL ENGINEERING GRADUATE, inexperienced, but with a sincere interest in teaching as a career wishes a position as instructor in electrical engineering, mathematics or physics in college or technical school; mathematics or physics in secondary school. Age 26, single. C-9205.

MECHANICAL ENGINEER, Purdue graduate, many years' experience in boiler work from fireman to plant engineer and manager of boiler shop. Interested in opening with power company or engineering department of industrial company, or with plate or structural shop. Experienced business manager and executive. Will consider teaching mathematics or structural design. B-5551.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.	205 West Wacker Drive	31 West 39th St.
San Francisco	Chicago	New York
N. D. Cook, Manager	A. K. Krauser, Manager	W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Membership

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before August 31, 1931.

Appel, I., New York City Board of Transportation, New York, N. Y.
Bagger, A. C., Commonwealth Edison Co., Chicago, Ill.
Ballantine, J. S., General Electric Co., West Lynn, Mass.
Banister, A. L., New England Power Co., Lawrence, Mass.
Bell, L. W., Southern California Edison Co., Ltd., Santa Monica, Calif.
Brandecker, F. A., (Member) U. S. Navy, Navy Yard, Mare Island, Calif.
Coleman, F. D., Montana Power Company, Billings, Montana
Gill, W. T. (Member) c/o Piedmont & Northern Railway Co., Charlotte, N. C.
Goodale, W. G., New England Power Co., Tewksbury, Mass.
Gradby, E. I., 1825 Norman Ave., Ridgewood, L. I., N. Y.
Haye, F., Industrial Electric Motor & Tool Co., New York, N. Y.
Hilts, H. D., General Electric Co., Schenectady, N. Y.
Holdrege, C. F., 1936 South 33rd St., Omaha, Nebraska
Knapp, L. G., c/o Montgomery Ward & Co., Inc., Chicago, Illinois
(Applicant for re-election)
Machiorlete, L., 648 Palisade Ave., West New York, N. J.
MacNaught, M. S., Hixon Electric Co., New York, N. Y.
Morgenstierne, C. O. M., Illinois Steel Co., Gary, Ind.
Munhall, W. F., 712 Filbert Street, Pittsburgh, Pa.
Norell, J. J., c/o Mrs. H. H. Smith, Middletown, N. J.
O'neill, W. J., 816 Central Ave., San Francisco, Calif.
Rhoades, C. O., General Petroleum Oil Co., Seattle, Wash.
Richardson, R. B., Mountain View, N. J.
Roberts, L. C., American Tel. & Tel. Co., New York, N. Y.
Shytle, D. E., Huntt Elevator Repair Co., Washington, D. C.
Sidler, P. R., Brown, Boveri & Co., Ltd., New York, N. Y.
Sleeper, C. L., Pacific Gas & Electric Co., San Francisco, Calif.
Stiegler, E. J., 663 The Alameda, Berkeley, Calif.
Swigart, J. I., Follansbee Bros. Co., Follansbee, W. Va.
Tompkins, H. K. V. (Member) Gulf Production Co., Houston, Texas
(Applicant for re-election)
Wagner, I. B., Lima Locomotive Works, Inc., Lima, Ohio
Weidlein, W. D., c/o Black & Veatch, Kansas City, Mo.
Wolfe, G. E., Lincoln Hotel, New York, N. Y.
Youngstrom, C. H., 451 West 47th St., Los Angeles, Calif.

33 Domestic

Foreign

Dordi, K. M. (Member) Tata Hydro-Electric Power Supply Co., Bombay, India
Kemeny P. (Member) Brazilian Telephone Co., Sao Paulo, Brazil, S. A.
Miller, W. J., c/o Ingenio Santa Fe, San Pedro de Macoris, Dominican Republican
Perry, F. R., Metropolitan-Vickers Electrical Co., Ltd., Manchester, England
Raghunath, N. V., The Indian Institute of Science, Bangalore City, South India
Roberts, F. W., Estler Bros., Ltd., London, Eng
Tatrey, S. S., Jalgon Electric Supply Co., Ltd., Jalgon, Bombay, India

7 Foreign

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING**

(August 1931) Number	Author	Title
☐ 31-13	J. H. Blankenbuehler	An Improved Arc-Welding Generator
☐ 31-17	F. B. Bramhall	Telegraph Transmission Testing Machine
☐ 31-40	J. B. Whitehead	The Conductivity of Insulating Oils
☐ 31-41	K. K. Palueff	Effect of Transient Voltages on Power Transformers—III—Non-Resonating Auto-Transformers
☐ 31-46	J. B. Whitehead and W. B. Kouwenhoven	Fundamental Properties of Impregnated Paper
☐ 31-47	H. H. Race	Some Electrical Characteristics of Cable Oils
☐ 31-63	F. C. Hanker (Chairman Subject Committee on Grounding)	Present Day Practise in Grounding of Transmission Systems—Second Report of Subject Committee on Grounding
☐ 31-66	G. Sutherland and D. S. MacCorkle	Burn-Off Characteristics of A-C. Low-Voltage Network Cables
☐ 31-74	C. L. Dawes and W. M. Goodhue	Equivalent Circuits of Imperfect Condensers
☐ 31-83	P. H. Moon	The Theory of Thermal Breakdown of Solid Dielectrics
☐ 31-95	J. B. Whitehead and F. Hamburger, Jr	Residual Air and Moisture in Impregnated-Paper Insulations—III
☐ 31-99	M. C. Holmes	Insulation Variability—Its Influence in Determining Breakdown Voltages
☐ 31-124	H. H. Skilling	Tuned Power Lines
☐ 31M2	S. B. Clark	A-C. Networks in Portland, Oregon
☐ 31M3	C. F. Green	Electrical Solutions of Problems of Regular Scheduled Flight

*Members, Enrolled Students and subscribers are entitled t one complete copy of any paper abridged if it is requested within one year from date of its publication in Electrical Engineering. Thereafter a charge of twenty-five cents per complete copy will obtain.

Name..

Address ....

Pleas order reprints by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at hte Engineering Societies Library, New York, during June are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Business Administration. By W. Wissler. N. Y., McGraw-Hill Book Co., 1931. 897 pp., diagrs., charts, tables, maps, 9 x 6 in., cloth, $5.00.——An interesting, readable presentation of the various factors that affect the problems which confront the administrator of business enterprises. Money, markets, men, machines, materials and methods are examined, and their relations to each other are discussed. A critical inquiry into the nature and ends of business as a complex institution aims to show executives where business stands today and the line along which it is developing.

Electric Clocks. By F. Hope-Jones. Lond., N. A. G. Press, 1931. 261 pp., diagrs., 9 x 6 in., cloth, 12s. 6d.——A combination historical and technical account of the evolution of the electric clock. Starting with Alexander Bain's patent of 1840, the author describes and criticizes the efforts of successive inventors and illustrates the steps that have led to the highly accurate devices of today. Numerous diagrams add to the usefulness of the book.

High-Speed Internal-Combustion Engine. By H. R. Ricardo. Lond. & Glasgow, Blackie & Son, Ltd., 1931. 435 pp., illus., diagrs., charts, tables, 10 x 7 in., cloth, 30 s.—A thorough analysis of the scientific basis of design, based upon extensive research and experimentation. General principles, rather than specific designs, are discussed in this important work, which will interest every designer. This is a new edition of the second volume of the internal-combustion engine. The principal change is the addition of a chapter on the high-speed Diesel engine.

Logic of Science. By Harold R. Smart. Lond. & N. Y., D. Appleton & Co., 1931. 237 pp., 9 x 5 in., cloth, 8 s 6 d.——A systematic discussion of the problems that lie on the borderland between science and philosophy, which endeavors to show what scientific concepts have to contribute to the philosophic problems of existence, value, mind and reality, and to apply the logical principles developed by philosophy to the discussion of scientific ideas. The aims and scope of natural science are examined, the relation of each science to its neighbors is shown, the emergence of the major problems is traced, and the proposed solutions are indicated.

Metallkeramik. By F. Skaupy. Berlin, Verlag Chemie, 1930. 60 pp., illus., diagrs., charts, 10 x 6 in., paper, 6-r. m.——This little book is the first to describe systematically the manufacture of articles from powdered metal by molding and sintering it. The preparation and properties of powdered metal and of articles made from it are first described generally. The manufacture of wire, sheet and molded articles from powdered tungsten, molybdenum, tantalum and other infusible metals is then treated. This is followed by a section on carbaloy and similar hard alloys. An appendix discusses some other possibilities of the process.

Principles of City Planning. By K. B. Lohmann. N. Y., McGraw-Hill Book Co., 1931. 395 pp., illus., diagrs., charts, maps, 10 x 6 in., cloth, $4.00.——Aims to give, in a single volume, an account of the whole subject of city planning. The elements and principles of the various branches are presented, and such general matters as the scope and importance of the work, its possibilities and the means of its accomplishment are discussed. City planning in the United States is stressed. Both the design of new cities and the improvement of existing ones are considered.

Relativity. By M. Palmieri. Los Angeles, Cal., Forbush Publ. Co., 1931. 87 pp., 11 x 8 in., cloth, no price indicated. ——A brief non-mathematical presentation of the theory of relativity, intended for lay readers who wish to understand its principles and consequences.

Die Werkstoffdämpfung bei Dreh- und Biegeschwingungsbeanspruchung. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, Heft 335.) By O. Föppl and G. Schaaf. Berlin, VDI-Verlag, 1930. 27 pp., charts, diagrs., 12 x 8 in., paper, 4.50-r. m.——Presents the results of an investigation of the damping properties of various metals when subjected to different stresses. Tests of each metal were made by different methods and compared.

Jet-Wave Rectifier. (Ingeniorvidenskabelige Skrifter, A Nr. 24). By J. Hartmann. Kobenhavn, Danmarks Naturvidenskabelige Samfund, 1931. 300 pp., illus., diagrs., charts, tables, 11 x 7 in., paper, price not given. (Published in English.)——This is a mechanical rectifier based upon a principle invented by Mr. Hartmann in 1907. Between the years 1919 and 1929 he was actively engaged in developing the apparatus for high-power rectification. We have here a detailed account of the work done during this period and of the results that have been attained, both experimentally and in practise. The rectifier is quite distinct in character from the mercury-arc rectifier but may be used for similar duties.

Mitteilungen aus den Forschunganstalten Ghh-Konzern, Bd. 1, Heft 3, pp. 45-68, February 1931. Berlin, V.D.I. Verlag, 12 x 8 in., paper, 3-r. m.——Four investigations are reported: the effect of surface condition upon the durability of various steels: a critical investigation of the standard method for dynamic tests; recent advances in welding and cutting cast iron and cast steel; and the measurement of fluids in motion by means of nozzles.

Patent Law for Chemists, Engineers and Executives. By F. H. Rhodes. N. Y., McGraw-Hill Book Co., 1931. 207 pp., 8 x 6 in., cloth, $2.50.——This book, written for engineers and business men, discusses the questions of interest to men engaged in technical and administrative work. The law of patents, the requirements for a patentable invention, the rights that a United States patent confers, and similar general matters are explained and illustrated by citations from court decisions.

Industrieöfen, v. 2. Bau und Betrieb. By W. Trinks. Berlin, V. D. I. Verlag, 1931. 398 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, 20-r. m.——This is the final volume of the German translation of the valuable book on industrial furnaces, the original of which is well-known to American engineers.

Royal Technical College Journal, Glasgow, January, 1931, Vol. 2, Part 3, pp. 371-566, paper, 10 x 7 in., 10s 6d.——Describes work in the fields of chemistry and engineering. Among the subjects investigated were the magnetostriction of overstrained materials, th transmission of heat in a fluid in turbulent motion, the rotating wheel with disk of constant stress ratio, pressure strains in non-circular drums, the influence of direct and shear stresses on the end constraints of curved bars, a standard of roughness for steam nozzles, torsional rigidity and web torque of crankshaft units and the effect of journal clearance, heat transmission coefficients for superheated steam, fuel pipe effects in mechanical-injection oil engines, the lubricating properties of mineral, vegetable and fatty oils, the wave form of the mercury-arc power rectifier, and the radiant efficiency and heat distribution of electric fires.

Underground Systems Reference Book. By National Electric Light Association. N. Y., The Association, 1931. 377 pp., illus., diagrs., charts, tables, 12 x 9 in., $4.00.——A number of leading American authorities has assisted in editing this description of accepted practise in the design, construction, and operation of underground systems of electric distribution. Cables and their insulation, conduit and manhole design and construction, cable installation, splices and terminals, cable operation, miscellaneous equipment and safety practises are discussed in detail. A bibliography of over 4,000 references is appended to the report.

Annual Survey of American Chemistry, vol 5, 1930. Edit. by C. J. West. N. Y., Chemical Catalog Co., 1931. 629 pp., diagrs., tables, 9 x 5 in., cloth, $5.00.——A concise summary of the progress in pure and applied chemistry made in America during 1930. This valuable review contains much to interest engineers, especially in the sections upon the X-ray examination of metals, the metallurgy of iron and steel, water, sewage, cement and concrete, coal, petroleum, gaseous fuels, and paints. The references to sources are very extensive and complete.

Selected Items From

Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Alloys

MAGNETIC. Nickel-Iron Alloys and Their Application to Instrument Construction, F. E. J. Ockenden. *Jl. Sci. Instruments*, vol. 8, no. 4, Apr. 1931, pp. 113-117, 3 figs. Investigation into magnetic properties of nickel-iron series has resulted in production of new class of magnetic materials, these materials having characteristics which render them superior to more usual silicon steels when used at inductions of less than 5,000 lines per sq. cm.; composition giving highest possible initial permeability is very closely 78 per cent nickel, 22 per cent iron; magnetizing and core loss curves. Bibliography.

MAGNETIC—HIPERNIK. Permeability of Hipernik Reaches 167,000, T. D. Yensen. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 386-388, 8 figs. To give electrical engineer data from which he can judge or calculate relative advantages obtainable by using hipernik, representative curves are given for hipernik and for 4 per cent silicon iron.

Alternators

COOLING. Systéme de protection pour alternateurs ventilés en circuit fermé (Protective Devices for Alternators with Circulating Air Ventilation), E. Haveaux. *Science et Industrie*, vol. 15, no. 208, May 1931, pp. 220-222, 4 figs. Review of increasingly severe conditions that high capacity turbo-alternators have to withstand and reasons why closed circulation ventilation is more and more applied; deficiency of actual protective devices in event of accidental failure in supply of air cooling water; simple device adapted to Valenciennes power plant alternators which, while consuming no auxiliary power, automatically converts ventilation into open circuit circulation.

Arcs

On the Theory of the Mercury Arc, K. T. Compton. *Phys. Rev.*, vol. 37, no. 9, May 1931, pp. 1077-1090, 4 figs. Theory of heat balance at cathode is extended by introduction of accommodation coefficient of neutralized ions, by evaluation of all processes which absorb energy gained by electrons in cathode fall space, and by correction of previous assumption that fields sufficient to extract electrons will affect heat of neutralization of positive ions at surface.

Potential Drop and Ionization at Mercury Arc Cathode, E. S. Lamar, and K. T. Compton. *Phys. Rev.*, vol. 37, no. 9, May 1931, pp. 1069-1076, 4 figs. By means of movable Langmuir collector, potential, ion concentration and electron temperature were measured at various distances from stationary mercury cathode spot, at various arc currents; results indicated cathode drop of 10.0 volts, and small negative potential gradient beyond fall space which was more pronounced at larger currents.

Cables

SHEATHS. Cable Sheath Damage and Protection. *Nat. Elec. Light Assn.—Pub.*, no. 127, May 1931, 17 pp., 17 figs. 35 operating companies contributed information on operating experiences; recent trend is indicated toward use of combination of asbestos and cement fireproofing; corrosion damage by d-c. electrolysis due to stray currents is in most cases being effectively combatted; much corrosion has been found in "green" concrete ducts due to chemical action of hydroxides in cement; remedial actions are suggested.

UNDERGROUND. Oil Reservoirs and Accessories for Underground Cables. *Nat. Elec. Light Assn.—Pub.*, no. 119, May 1931, 12 pp., 19 figs. Companies using oil reservoirs in which air or gas is in contact with oil under pressure report satisfactory operation; various types of reservoirs manufactured have proved satisfactory; some companies have found some of bellows type reservoirs to have rather short, useful life; in few cases, accessories and fittings have become defective in service.

Circuit Breakers

Fundamentals the Essence in Circuit Interruption, J. D. Hilliard. *Elec. World*, vol. 97, no. 18, May 2, 1931, pp. 809-811, 1 fig. Phenomena in oil circuit breakers are admittedly complex, but clarity will result if fundamental happenings in all types of breakers are segregated from those which make one type behave differently from another and even one model from another of same general type; much of confusion surrounding subject of circuit interruption results from failure to recognize common elements of all methods of circuit breaking as distinct from factors introduced by variations in design.

The Expansion Circuit Breaker, F. Kesselring. *Elec. Rev.*, vol. 108, no. 2791, May 22, 1931, pp. 859-861, 12 figs. Underlying principles; characteristic curves showing breaking distance; abiadatic expansion; entropy; saturated water-vapor pressure temperature; circuit rupture oscillograms; transportable wall-mounting, and outdoor types of expansion circuit breakers; illustrated comparison as to size between expansion and oil breaker chambers.

Conductors

IRON AND STEEL PLANTS. Conductors of Heavy Alternating Currents, D. I. Bohn and H. W. Pabst. *Iron and Steel Eng.*, vol. 8, no. 6, June 1931, pp. 253-256, 7 figs. Design data and curves for heavy a-c. conductors in steel mills; it is desirable to limit conductor temperature rise to 3 deg. cent., largely to assist in maintaining reasonable temperatures of connected equipment; pipe size of tubular copper and aluminum conductors with capacities for 30-deg. cent. rise at 60 cycles; channel conductor ratings for pairs of aluminum channels arranged to form square, temperature rise 30 deg. cent. over 40-deg. cent. ambient, at 60 cycles.

Dielectrics

Dielectric Properties of Matter, S. O. Morgan. *Bell Laboratories Rec.*, vol. 9, no. 10, June 1931, pp. 462-469, 7 figs. Molecular study, it is shown that methane is symmetrical and therefore non-polar; that in non-polar molecule centers of opposite charge coincide, in polar molecule they do not; potential applied to polar substance tends to shift its molecules from their random orientations; tetrachloromethane is symmetrical and therefore non polar, etc.

BREAKDOWN. Breakdown Voltage as a Function of Electrode Area and Dielectric Homogeneity, M. O. Holmes. *Franklin Inst.—Jl.*, vol. 211, no. 6, June 1931, pp. 777-779. If number of samples of insulation, all apparently similar as regards composition, thickness and area, are subjected to breakdown tests made under identical test conditions, they will not all fail at same value of voltage but, due to inherent inhomogeneities in composition of individual samples, will show variations in breakdown voltage; number of tests made in samples of unit area; voltage distribution of results represented is analyzed.

Education

ILLUMINATING ENGINEERING. Educational Training in the Lighting Art, P. S. Millar. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 5, May 1931, pp. 415-423. Paper was prepared at request of committee which organized present symposium on training for lighting work; it puts forward writers view that scope of lighting art is so broad that it requires of successful practitioner, a comprehensive acquaintance with fundamentals of science and of art with broad cultural background; without discussing in detail procedure in lighting education, it offers suggestion that models may be employed advantageously in such training.

Electric Drive

IRON AND STEEL PLANTS. Electrical Auxiliaries in Steel Mills, D. W. Dean. *Iron and Steel Engr.*, vol. 8, no. 6, June 1931, pp. 199-208, 9 figs. Successful steel plant of future will be one that maintains well planned program for improvements in their auxiliary drives, as well as for their main drives below 30 hp.; matter seems of minor importance, but when we consider that total investment in electrical auxiliaries usually exceeds total investment in main drives it becomes apparent that careful consideration is justified.

How to Get the Most Out of Control in Steel Mills, P. B. Harwood. *Maintenance Eng.*, vol. 89, no. 6, June 1931, pp. 294-296, 3 figs. Requirements for maximum service are select control designed to meet conditions of installation; apply proper motor and control for drive; install equipment properly; maintain it adequately.

LOOMS. The Individual-Motor Loom Drive as Viewed Today, W. A. Mayor. *Textile World*, vol. 79, no. 24, June 13, 1931, pp. 32-33, 3 figs. Advantages of individual drive.

OIL WELL PUMPING. Electrical Installation of Motors and Transformers, E. L. Spaugh. *Oil Weekly*, vol. 61, no. 4, Apr. 10, 1931, pp. 39-41 and 44, 5 figs. Notes on equipment of Rio Bravo Oil Co., in Guffey, Humble, Luling, Pierce Junction and Saratoga oil fields; outline of approved practise; motor housing, foundation, and installation; transformers; power lines for pumping circuit; lighting circuit; general maintenance; hazards of electrical work.

Electric Equipment

IRON AND STEEL PLANTS. Electrical Developments Committee Report—1930-1931, W. H. Burr. *Iron and Steel Engr.*, vol. 8, no. 6, June 1931, pp. 233-240, 12 figs. During year 1930, 109 main roll drives of 300-hp. or over were installed as compared with total of 201 during previous year; total hp. in main roll drives installed during year was 158,440 as compared with total of 313,000 during previous year; charts showing installed power in various types of mills.

Electric Power

BUILDINGS. Tradition Broken with All-Electric Building, H. T. Crane. *Elec. West*, vol. 66, no. 5, May 1, 1931, pp. 228-232, 17 figs. New headquarters of Southern California Edison Co., Ltd., embody practical application of electricity for all requirements of modern office structure; complete building equipment designed for 100 per cent utilization of electric energy; system and equipment is described.

LUMBER INDUSTRY. Electric Power in the Lumber Industry, A. H. Onstad. *Timberman*, vol. 32, no. 7, May 1931, pp. 36-39 and 42, 9 figs. Highly specialized applications of motor drives evolved for western sawmill and logging service; review of specific application of electric power and equipment.

Elevators

ELECTRIC. Miniature Elevator Enters the Home, C. C. Crispen. *Elec. Jl.*, vol. 28, no. 6, June 1931, p. 379, 4 figs. Latest device for household, called "Inclinator," is traveling car or chain mounted on roller truck running in steel channel alone one side the stairway; when not in use platform and two seats fold up in single movement against metal back, requiring only five in. of space; car designed for vertical ascent is used when stairs are winding.

Engineering

A Half Century of Electrical Engineering, C. F. Scott. *Engrs' Soc. West. Pa.—Proc.*, vol. 47, no. 4, Apr. 1931, pp. 224-225, 16 figs. Historical review of development; conditions 50 years ago; electricity in steel industry; mining and transportation; communication; electricity supplants muscle, skill, and judgment; tools, methods, and men; data regarding electrical development; new industrial revolution; problems created by electricity; chronological review of telephone with special reference to Pittsburgh district.

INFLUENCE ON CIVILIZATION. The Engineer—His Part in Present and Future Civilization, S. S. Arentz. *Professional Engr.*, vol. 16, no. 5, May 1931, pp. 4-6. It is claimed that, just as engineer is leader in bringing about mass production, and invention of labor-saving devices, he can with equal effect bring about solution of problems that must be solved in order to eliminate repetition of such times as world is passing through today. Before Am. Assn. Engrs.

Engineers

What the Engineers Are Doing, A. D. Bailey. *Elec. World*, vol. 97, no. 24, June 13, 1931, pp. 1146-1147. As our industry develops, as our service expands in its present fields and extends into new, technical details involved and problems to be met are bound to increase rather than to diminish both in number and importance; engineers will be needed who not only possess high technical qualifications but who are blessed with ambition and imagination as well; men who are trained to analyze and to think straight. Before Nat. Elec. Light Assn. Annual Convention.

Gages

PIEZOELECTRIC. Piezo-Electric Gage and Amplifier, R. A. Webster. *Franklin Inst.—Jl.*, vol. 211, no. 5, May 1931, pp. 607-616, 7 figs. Pressure gage was designed and built using cartridge of pure bakelite; within this was placed pile of 21 quartz crystals, each 0.69 in. sq. by 0.053 in. thick, they being separated by platinum electrodes; screwed brass ends held them in cartridge which was then sealed with beeswax; 3/8-in. piston bore upon this pile; this gage has given very good service and although few of crystals cracked, no loss in sensitivity has been noticed.

Galvanometers

SUSPENSIONS. Note on Julius Suspensions, M. J. Brevoort. *U. S. Bur. Mines—Report of Investigations*, no. R. I. 3086, Mar. 1931, 2 pp., 1 fig. on supp. plate; see also *Instruments*, vol. 4, no. 5, May 1931, pp. 277-278, 1 fig. Research work in Bureau of Mines cryogenic laboratory requires use of high-sensitivity galvanometers of d'Arsonval type in building that is subject to unusually severe vibrations; modified form of galvanometer suspension described by Julius in Annalen Physikalische Chemie of 1895, has damped vibrations successfully.

Generators

D-C. DESIGN. Relation of Coil and Brush Current in a Direct-Current Machine, R. M. Baker. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 383-386, 3 figs. General expression for current and voltage relations in armature coil; magnitude of circulating current in brushes; effect of over-compensation.

WATERWHEEL. A Comparison of Exciters for Waterwheel Generators, T. J. Woth. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 343-344, 3 figs. There are three principal types of exciters for waterwheel generators; direct-connected, separate turbine driven, and motor-generator set; advantages and disadvantages of each have important bearing on design and cost of complete station.

Heating

HEAT STORAGE. Solid-Core Thermal-Storage Heating Units, L. G. A. Sims and K. R. Sturley. *Engineering*, vol. 131, nos. 3407 and 3410, May 1, 1931, pp. 561-564, and May 22, pp. 664-665, 23 figs. Systems heretofore employed in Great Britain are not convenient in cases where single small rooms and single offices have to be heated; for this purpose, unit type of heater is needed, having loading of few kilowatts only, capable of being installed without alteration to structure of building; results of experiments made in Electrical Engineering Department of University of Birmingham on one of best Continental heaters, and development of greatly improved design.

Hoover Dam

Hoover Dam Will Provide 1,000,000 Hp. *Power Plant Eng.*, vol. 35, no. 12, June 15, 1931, pp. 643-645, 2 figs. Great project of Bureau of Reclamation includes dam 730 ft. high at Black Canyon on Colorado River, power plant, diversion and water control works and other features; general plan and section of Hoover dam, showing cofferdams and diversion tunnels.

Hydroelectric

POWER DEVELOPMENTS. A Power Development on the Columbia River, T. B. Parker. *Stone and Webster Jl.*, vol. 48, no. 5, May 1931, pp. 331-345, 7 figs. Rock Island hydroelectric development on Columbia River 12 mi. downstream from City of Wenatchee, Washington is built for Puget Sound Power and Light Co.; development will have several novel features, and will be first large low head development in Northwest it will be designed for ultimate capacity of 150,000 kw. under normal head of 48 ft.; initial installation will be 60,000 kw.

Power Plants

PUMPED STORAGE. Pumped Storage for Regeneration, L. F. Harza. *Power Plant Eng.*, vol. 35, no. 2, June 1, 1931, pp. 597-601, 4 figs. Methods of storing energy on large commercial scale; European practise of pumped storage power; pump-fed storage plants in Germany; design and operation features of several large plants in Germany; list of advantages and disadvantages of hydraulic storage; efficiency of conversion; economical capital expenditure limit.

REMOTE CONTROL. Automatic and Remotely Controlled Hydro-Power Plant. *AEG Progress*, vol. 7, no. 5-6, May-June 1931, pp. 99-106, 8 figs. Review of automatic and remotely controlled plant on basis of experience accumulated by AEG is construction of numerous automatic hydro-power stations for output totalling well over 100,000 kw.; important factors requiring study when planning electrical section of small and medium sized stations.

Insulating Materials

RUBBER. Rubber for Electrical Uses, A. R. Dunton and A. W. Muir. *Elecn.*, vol. 106, no. 2762, May 8, 1931, pp. 679-681, 1 fig. Vulcanization; tapes, flexible wire and cable insulation; ebonite and vulcanite; molding difficulties.

SPECIFICATIONS. Report of Committee D-9 on Electrical Insulating Materials. *Am. Soc. Testing Mills—Advance Paper*, no. 74, for mtg. June 22-26, 1931, 25 pp., 3 figs. Recommendations affecting standards and tentative standards; subcommittee I on insulating varnishes; subcommittee II on molded insulating materials; subcommittee on sheet insulation; subcommittee IV on liquid insulation; subcommittee VII on electrical tests; section A, of subcommittee IV, on neutralization methods for electrical insulating oils; electrometric methods for determination of neutralization number of mineral insulating oils.

Lamps

INCANDESCENT. Report of the Lamp Committee—June, 1931. *Nat. Elec. Light Assn.—Pub.*, no. 136, June 1931, 8 pp., 10 figs. Statistical data, covering incandescent-lamp industry; lamp developments that have taken place during year; importance of applying proper voltage lamp to obtain most economical and best results.

TUNGSTEN. Production of Color from Tungsten Lamps, M. Luckiesh. *Elec. World*, vol. 97, no. 14, Apr. 4, 1931, p. 645. Amount of light emitted in each of spectral regions by various sizes of tungsten lamps is listed.

Lighting

The Art of Illumination—II, J. W. T. Walsh. *Illum. Engr.*, vol. 24, May 1931, pp. 111-114. Specimen installations in many different classes of lighting problems ordinarily met with in practise.

AUTOMATIC CONTROL. The Automatic Control of Lighting Installations, E. H. Vedder and S. G. Hibben. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 5, May 1931, pp. 517-523 and (discussion) 523-525, 8 figs. on supp. plates. Changing customs and requirements that impose more difficult demands upon manual control of many lighting circuits, have brought about logical development of automatic light-sensitive switching devices; photoelectric tube constitutes foundation of automatic control units, which, with its accessories and typical assembly, is described briefly; several actual and some suggested applications are mentioned, that seem destined to widen service to which artificial light will soon be put.

BUILDINGS. Electric Light on Metal in Architecture, E. Clute. *Elec. Specifications*, vol. 3, no. 5, May 1931, pp. 14-22, 11 figs. First of series of articles on materials in combination with electricity; examples showing effects of amber light on nickel grill and aluminum leaf of recessed light source, walls of black marble of light on nickel-chrome steel of reflector casings, crestings of store fronts and doors, red marble walls with buff veining on corrugated white metal backing of recess, grille of carved satinwood painted in polychrome; lighting and floodlighting features of various outstanding buildings of recent date are illustrated.

Lightning Arresters

TESTING. Cathode-Ray Oscillograph Tests Arrester Production, O. A. Ackermann. *Elec. World*, vol. 97, no. 19, May 9, 1931, p. 866, 2 figs. Criterion for acceptability of unit blocks which make up autovalve lightning arrester is volt-ampere curve; Westinghouse Electric & Manufacturing Company is using cathode-ray oscillograph in connection with surge generator for purpose of testing; oscillograph used for this purpose is of glass tube type, developed in Westinghouse Company originally for television purposes.

Lightning Protection

HIGH TENSION LINES. 220-Kv. Arrester on Long Line, G. C. Dill. *Elec. World*, vol. 97, no. 18, May 2, 1931, pp. 804-806, 6 figs. Hydro-electric power commission of Ontario recently has placed on 220-kv. side of Leaside substation near Toronto unique and notable installation of four 3-phase SV autovalve lightning arresters; protection problem was difficult; it would require 22 units to handle these dynamic over-voltage conditions of 266 kv. line to ground; arresters that were decided upon meet these two requirements by new and very unique design.

Loud Speakers

A Loud Speaker Good to Twelve Thousand Cycles, L. G. Bostwick. *Bell Laboratories Rec.*, vol. 9, no. 9, May 1931, pp. 433-436, 5 figs. In loud speaker under discussion, factors that usually cause high frequencies to be suppressed have been taken into consideration; diaphragm is made of .002-in. duralumin and is little over one inch in diameter; moving coil of aluminum ribbon wound edgewise is attached to diaphragm at periphery of embossed section and vibrates in very strong magnetic field in usual way; diaphragm and moving coil weigh together but 160 mg.

MOVING COIL. The Moving Coil Loud Speaker, H. M. Clarke. *Experimental Wireless*, vol. 8, no. 93, June 1931, pp. 304-306, 2 figs. If no allowance is made for possible change in electrical constants, dynamic impedance attributed to moving system and measured by difference of input resistance and reactance of system when in motion, from those of system at rest, may be considerably in error; with view to observing possible existence of such changes, author has carried out experiments.

Magnetic Hardening

METALS. Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. *Metallurgia*, vol. 3, no. 18, Apr. 1931, pp. 219-221, 8 figs. Author describes his discovery of remarkable changes produced in metals by action of rotating magnetic field; hardening of alloy steels; application to non-ferrous metals, such as duralumin, rod brass and brass sheet.

Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. *Metallurgia*, vol. 4, no. 19, May 1931, pp. 9-13, 17 figs. New developed magnetic phenomena is applicable to hardening of tools of any type or design; treatment occupies not more than two minutes at temperatures not exceeding 200 deg. cent.; data on experiment with alloy steels, duralumin and brass; graphs indicating results and comparison with other hardening processes. Bibliography.

Magnetic Testing

IRON AND STEEL. Relation Between Magnetic Properties, Impact Strength and Hardness, H. Styri. *Am. Soc. Testing Matls.—Advance Paper*, no. 33, for mtg. June 22-26, 1931, 12 pp., 4 figs. Results of investigation of subcommittee of Society's Committee A-8 on magnetic analysis, formed to investigate relationship between magnetic testing and impact strength and hardness; results are summarized in graphical form.

Magnets

DESIGN. Permanent Magnets for Electronic Instruments, W. H. Hoppe. *Electronics*, vol. 2, no. 5, May 1931, pp. 636-638, 3 figs. Permanent magnets represent inconspicuous but important part of many electronic devices, *e. g.*, measuring instruments, sound pickups and other well-known apparatus; principles of design of such magnets are described.

Measurements

Accurate Measurement of Small Electric Charges by a Null Method, L. S. Taylor. *U. S. Bur. Standards—Jl. Research*, vol. 6, no. 5, May 1931, pp. 807-818, 5 figs. partly on supp. plate. New method for calibrating null system in such manner that capacity of leads does not enter and which, therefore, permits reduction in calibration error to one-tenth; when system is once calibrated in manner described, any unknown capacity whatever may be added to leads without affecting measurement of desired quantities; applications to measurements of current, charge and capacity.

Measuring Instruments

Electrical Maintenance Instruments, A. I. Greenwood. *Power Plant Eng.*, vol. 35, no. 12, June 15, 1931, pp. 669-670, 4 figs. Grounds and insulation tests with discussion of methods and instruments used in making them; accurate resistance measurement.

Metering

THREE-PHASE. The Metering of Three-Phase Supplies, O. Howarth. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 413, May 1931, pp. 637-646, 3 figs. Discussion by A. E. Moore, A. E. Jepson, A. M. Strickland and others, of paper previously indexed from issue of Mar. 1931; also reply by author.

Meters

Meter Committee Reports. *Elec. West.*, vol. 66, no. 6, May 15, 1931, pp. 385-401, 25 figs. Reports of Pacific Coast Electric Association on meter obsolescence; reactive kva. metering; special tests and investigations; determining ground resistance; calibration of high voltage potential transformers using standard of different voltage rating; oscillographic measurement of time intervals; tests on various forms of relays; operating problems of meter department.

Motors

CAPACITOR. The Design of Capacitor Motors for Best Starting Performance, B. F. Bailey. *Univ. Mich.—Dept. Eng. Research—Eng. Research Bul.*, no. 19, Apr. 1931, 23 pp., 12 figs. Having been called upon to design large number of capacitor motors, writer has endeavored to simplify fundamental theory and methods of making necessary computations; portion of theory which relates to locked or starting torque of capacitor motors is presented in its simplified form.

SQUIRREL CAGE. Full-Voltage Starting Simplifies A-C. Motor Applications, E. W. Henderson. *Power*, vol. 73, no. 20, May 19, 1931, pp. 770-772, 7 figs. Squirrel-cage motors have been developed that can be started by connecting them directly to line and yet maintain inrush current within N.E.L.A. recommendations; these motors have full-speed characteristics practically as good as those started on reduced voltage, and employ much simpler and less expensive starting equipment.

THREE-PHASE. Three-Phase Commutator Motors for Outputs Up to 16-5 kw., M. Mogensen. *Brown Boveri Rev.*, vol. 18, no. 6, June 1931, pp. 187-195, 22 figs. For many years Brown, Boveri & Co., have made complete range of three-phase commutator motors intended for textile industry for variable speed individual drive of ring spinning and twisting frames; they have also found many other fields of application; range of motors has undergone repeated improvements; new series of three-phase commutator motors thus formed is described in greater detail.

Networks

CURRENT CONVERSION. Planning Successive Steps in Network Cut-over, C. W. Evans. *Elec. World*, vol. 97, no. 20, May 16, 1931, p. 909, 1 fig. 13-kv. feeders formed nucleus from which small sections were gradually enlarged until two or three sections could meet and merge into one; this gradual expanding of smaller section was greatly simplified by secondary junction boxes, which were already installed in most manholes; since these boxes are provided with links it was simple matter to sectionalize new system from old.

DESIGN. A Non-Mathematical Analysis of the Measurement of Symmetrical Components, A. P. Hayward. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 351-357, 17 figs. Simple, non-mathematical analysis of physical basis of measurement. Bibliography.

OVERVOLTAGES. Over-Voltage Problems, A. H. Von Altmann. *Engineer*, vol. 151, no. 3934, June 5, 1931, pp. 634-635, 5 figs. Attempt is made to show that most dangerous over-voltages are caused by direct lightning strokes; proposals submitted in recent years for protecting overhead lines and plant; apparatus used for combating overvoltage phenomena.

UNDERGROUND. Underground Systems Reference Book. National Electric Light Association. N. Y., The Association, 1931, 377 pp., illus., diagrs., charts, tables, $4.00. Number of leading American authorities have assisted in editing this description of accepted practise in design, construction and operation of underground systems of electric distribution; cables and their insulation, conduit and manhole design and construction, cable installation, splices and terminals, cable operation, miscellaneous equipment and safety practises are discussed in detail. Bibliography of over 4,000 references. Eng. Soc. Lib., N. Y.

Ohmmeters

VACUUM TUBE. A Thermionic Megger with Linear Scale, O. Stuhlman. *Franklin Inst.—Jl.*, vol. 211, no. 5, May 1931, pp. 617-625, 5 figs. Writer proposes to use any tube with dynatron characteristics; if change in slope of given phase of characteristic can be shown to change in proportion to change in external resistance it should follow that for predetermined current, voltmeter recording potential across filament and plate can then be calibrated to read resistances directly; voltmeter's linear scale is then direct reading megohmmeter.

Photoelectric Cells

Concerning the Grid-Leak of a Grid-Photoelectric Tube, T. Asada and K. Hagita. *Inst. Elec. Engrs., Japan—Jl.*, vol. 51, no. 2, Feb. 1931, pp. 99-102, 5 figs. In previous paper on "Supersensitive Photoelectric Tube," it is reported that so-called grid-photoelectric tube or grid-tube is much more sensitive than other ordinary photoelectric tubes, and it has no phenomena of time-lag and fatigue; in this paper it is reported that this connection of grid with filament through a high resistance, which is similar to grid-leak of a triode, is very important for grid-tube. (In Japanese with English abstract on pp. 17-19.)

INDUSTRIAL APPLICATIONS. Power Control by Means of Phototubes, W. R. G. Baker, A. S. Fitzgerald and C. F. Whitney. *Electronics*, vol. 2, no. 5, May 1931, pp. 632-633, 6 figs. Use of phototube in various fields; wiring diagrams of light-operated relay circuit, system controlling power by light beams, Selenium-Thyratron system for illuminating control and smoke-density recorder circuit; color comparator by which phototube matches roast of coffee.

Power Factor

IMPROVEMENT. Alignment Charts for Power Factor Improvement, W. A. Barclay. *Elec. Engr. Australia and New Zealand*, vol. 8, no. 1, Apr. 15, 1931, pp. 19-22, 3 figs. Use of two charts, which author has drawn up, in determining size of condenser required for correcting power factor of circuit by specified amount; charts bring calculation of corrective kva. to simplest possible terms.

Power-Factor Correction Cuts Costs, J. F. Wulfetange, Jr. *Elec. World*, vol. 97, no. 14, Apr. 1931, pp. 628-631, 3 figs. Industrial plants in Pittsburgh, Pa., are encouraged to correct power factor by new "W" rate of Duquesne Light Co., offering low energy rates for high power factor demands; capacitors have proved economical, effective means of raising kw./kva. ratio either in supplementing or in substitution for synchronous machines.

Protection

HIGH TENSION LINES. The Petersen Coil for Power System Arc Suppression, W. F. Mainguy. *Elec. News*, vol. 40, no. 10, May 15, 1931, pp. 47-49 and 58, 3 figs. Short review of European development; notes on principle of coil which is applicable only to ungrounded system; solidly grounded neutral system; isolated neutral system; size of coil; connection of coil.

Radio

AMPLIFIERS—COUPLING. Theory and Operation of Tuned Radio-Frequency Coupling Systems, H. A. Wheeler and W. A. MacDonald. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 5, May 1931, pp. 738-803 and (discussion) pp. 804-805. Gain of amplifier can be held uniform or made to vary with frequency in any desired manner consistent with amplifying ability of tube and tuned secondary circuit, and without appreciable loss of selectivity; large variety of these improved coupling circuits is shown and classified in terms of fixed and varying components of equivalent mutual inductance; number of these coupling systems from commercial receivers are described in terms of coil structure, electrical constants, and performance.

BROADCASTING. Radio Network Broadcasting, R. H. Owen and W. G. Rubel. *Engrs. Bul.*, vol. 15, no. 4, Apr. 1931, pp. 5, 28-29 and 35, 2 figs. Discussion is intended to give more or less comprehensive idea of what is involved in connection with network broadcasting; present day program transmission circuits in United States are on "voice frequency basis"; in transmitting programs over wire network, it is important that volume range be held within proper limits; it is one of obligations of one who handles program pick-up to hold his range of volume between proper limits.

BROADCASTING, LONG WAVE. Low-Frequency High Power Broadcasting as Applied to National Coverage in the United States, W. H. Wenstrom. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 6, June 1931, pp. 971-983, 3 figs. With P. P. Eckersley's general theory derived from north European practise as starting point, possibilities of broadcasting in United States on frequencies around 200 kc. are examined from viewpoint of national coverage; it is shown that under specified conditions Eckersley's curves can be applied approximately to American terrain.

DIRECTION FINDING. The Practical Correction of a Wireless Direction-finder for Deviations due to the Metalwork of a Ship, C. E. Horton. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 195-198, 11 figs. Brief review of errors that may occur was due to immediate surroundings of direction-finder as in a ship. Before Inst. Elec. Engrs.

TELEPHONE, SHORT WAVE. Single Side Band Short-Wave Wireless Telephony. *Engineer*, vol. 51, no. 3932, May 22, 1931, pp. 570-571, 4 figs. New system of radio telephony in which single side band is applied to short-wave transmission, was demonstrated at experimental radio station of Matérial Téléphonique at Trappes, near Paris; results represent reward of long search for means of applying single side-band method, with its well-known advantages, to short-wave radio transmission, problem that has hitherto presented almost insurmountable difficulties.

ULTRA-SHORT WAVE. Communication on the quasi-optical frequencies, E. Karplus. *Electronics*, vol. 2, no. 6, June 1931, pp. 666-667, 4 figs. Problems in communication waves in Barkhausen and Kurz range; various laboratory equipment; transmitter and receiver by I. T. & T. experiments across English Channel on wavelength of 18 cm.; notes on problems of reception; ultra-high frequency wavemeters.

Railroads

AUTOMATIC CONTROL. Automatic Operation at the Cleveland Union Terminals, F. E. Jaquay. *Gen. Elec. Rev.*, vol. 34, no. 6, June 1931, pp. 350-356, 9 figs. Automatic and supervisory control which has now been in successful operation for nearly a year on Cleveland Union Terminal Electrification is very important part of this project which, at time of placing in service, was first application of 3,000 volts d-c. for heavy electric traction in east; electrified zone includes total of approximately 17 mi. of route and some 60 mi. of single track; importance of 100 per cent reliability in operation of this system handling between 100 and 150 trains daily is stressed.

REGENERATIVE CONTROL. Railway Regenerative Braking, J. A. Colaco. *Elec. Rev.*, vol. 108, no 2793, June 5, 1931, pp. 945-946, 4 figs. General improvement in operating conditions, more than saving in energy consumption, has justified adoption of system on Great Indian Peninsula railway.

SIGNALS AND SIGNALING. The Effect of Signalling on Track Capacity, C. R. Byrom. *Inst. Transport—Jl.*, vol. 12, no. 7, May 1931, pp. 326-340 and (discussion) 340-347, 8 figs. Historical review of signal developments; automatic signals; route indicators; manual versus automatic signaling.

SIGNALS AND SIGNALING, AUTOMATIC. N. Y. C. Re-Signals Tracks Entering Grand Central Terminal. *Ry. Age*, vol. 90, no. 18, May 2, 1931, pp. 856-858, 3 figs. Train operation in either direction on each of four tracks facilitates traffic and increases track capacity; track and signal plan of territory between Grand Central Terminal and Mott Haven; outline of new signaling system.

TRAIN CONTROL—CAB SIGNALING. Taking the Flicker Out of Cab Signal Lights. *Ry. Elec. Engr.*, vol. 22, no. 5, May 1931, pp. 119-121, 5 figs. Both track and locomotive irregularities may result in fluctuating indications; close attention to relay pick-up values and track circuit conditions will remedy trouble causes of fluctuating indications; typical 60-cycle loop system of continuous control, double track; typical coder continuous track circuits, track d-c. control and a-c. signal circuit.

UNITED STATES. 1930 a Difficult Year for the Electric Railways, E. J. Murphy. *Aera*, vol. 22, no. 5, May 1931, pp. 260-266. Sharp reduction in traffic and revenues produced by business depression severely taxed resources of industry in 1930; only by again stepping up operating efficiency and, in addition, closely adjusting service to reduced volume of business were they able to meet all obligations; tabular review of combined operations of electric railroad companies for 1929 and 1930.

Rate Making

POWER INDUSTRY. More Equitable Rate Forms an Industry Obligation, T. O. Kennedy. *Elec. World*, vol. 97, no. 22, May 30, 1931, p. 1008. With rate schedules based on rate per kw-hr. it is only natural that our customers should look upon electricity as commodity, whereas it can equitably be sold and charged for only as service; it is obligation of our commercial departments to promote adoption of more equitable type of rate.

Reactive Power

METERING. Reactive Kva. Metering—VIII, E. C. Goodale. *Elec. West.*, vol. 66, no. 5, May 1, 1931, pp. 233-234, 3 figs. Three-element meters give accurate registration of reactive Kva. on four-wire circuits if voltages are balanced.

Rectifiers

MERCURY-ARC. Mercury-Arc Power Rectifiers—Their Construction and Operation, W. E. Gutzwiller. *Power*, vol. 73, no. 24, June 16, 1931, pp. 950-953, 7 figs. Mercury-arc power rectifiers have in few years been developed to where they are now keen competitor of rotary converters and motor-generator sets; built in siz up to 6,000 kw., for voltages up to 3,000 and to supply all kinds of d-c. loads; cross-section through large mercury-arc power rectifier; diagram of connections for 6-phase manually operated rectifier unit.

Mercury Arc Rectifier for Electric Railroads, L. G. Raschkovsky. *Electriichestvo*, no. 9, May 1931, pp. 466-469, 5 figs. Characteristic properties; advantages over synchronous con verters; application on electric locomotives.

3,000-Volt Traction Rectifiers. *Engineer*, vol. 151, no. 3933, May 29, 1931, pp. 606-607, 2 figs. In electrification program by Delaware, Lackawanna and Western Railway, for converting 60-cycle a-c. into 3,000-volt d-c., mercury-arc rectifiers were chosen, in preference to motor-generators, because of their relatively low first cost, high efficiency, and ability to carry heavy overloads without injury; other advantages are small floor space and simple foundations. From article, by E. L. Moreland, previously indexed from Gen. Elec. Rev., Mar. 1931, under classification of Railroad Electrification—United States.

Relays

HIGH TENSION LINES. Theory and Application of Relay Systems—Ground-Fault Protection of Loop Systems—I, P. H. Robinson and I. T. Monseth. *Elec., Jl.*, vol. 28, no. 6, June 1931, pp. 375-378, 5 figs. For simple loop system consisting of one generating station and having transformer neutrals grounded at only this one point, impedance or directional-overcurrent ground relays are most frequently applied; more complicated systems require use of other types of relays; loop system with one grounded neutral point discussed.

TESTING. Some New Information Regarding the Installation and Testing of Brown Boveri Distance Relays, J. Stoecklin. *Brown Boveri Rev.*, vol. 18, no. 5, May 1931, pp. 175-179, 7 figs. Brown Boveri distance relay protection has been adopted to great extent in short time, and valuable suggestions have more than once been made by users with view to simplifying installation of relays, and also to render possible carrying out of periodical tests.

Remote Metering

The Midworth Distant Repeater. *Elec. Engr. Australia and New Zealand*, vol. 8, no. 1, Apr. 15, 1931, pp. 22-24, 4 figs. Instrument for providing remote indication of various values, and of its application for measuring bulk electricity supplied to Melbourne city council.

Substations

Laconia Avenue Distribution Station of the Bronx Gas and Electric Company, S. Wilder. *Gen. Elec. Rev.*, vol. 34, no. 6, June 1931, pp. 374-376, 5 figs. Purpose of article is not to present details of design or operation of automatic supervisory equipment but rather to describe briefly typical substation, furnished with such equipment, and to give some operating data in regard to installation; electrical energy purchased from United Electric Light and Power Co. is supplied over 13,200-volt feeders from this company's Sherman Creek and Hell Gate stations.

Switchboards

MINIATURE. Miniature Switchboards: A New Type of Control Switchboard for Electric Power Stations and Substations, P. Sporn. *Gen. Elec. Rev.*, vol. 34, no. 6, June 1931, pp. 336-342, 10 figs. Purpose and development of miniature switchboard; description of board and equipment; installations; advantages; experience in service.

Switchgear

Substation Switchgear, F. C. Orchard. *Elec. Times*, vol. 79, no. 2066, May 28, 1931, pp. 963-964, 3 figs. Main principles underlying design of substation are that apparatus shall be of sound design and construction so that breakdown is infrequent and apparatus shall be arranged so that it can operate under conditions for which it is designed; design of switchgear, which is most important apparatus in substation, is very largely effected by characteristics of high voltage system and not entirely by service to be given by substation.

AUTOMATIC. Automatic Switching Equipment in Industry, F. P. Brightman. *Gen. Elec. Rev.*, vol. 34, no. 5, May 1931, pp. 284-287, 4 figs. Applications in mines, steel mills, paper mills, and glass industry preferred-emergency service; advantages derived from use of automatic equipment are elimination of full time operator, of difficulties attributable to inefficient manual operation; reduction in feeder losses; reduction in number and duration of outage.

METAL CLAD. Metal Clad Switchgear. *Elec. West*, vol. 66, no. 6, May 15, 1931, pp. 334-339, 9 figs. "Report on types used and typical installations by Electrical Apparatus Committee of Pacific Coast Electric Association.

Telephone

Recent Development in Telephony, E. H. Colpitts. *Military Engr.*, vol. 23, no. 129, May-June 1931, pp. 247-254, 9 figs. Growth and improvements in toll circuits; toll cable improvements; gas pressure testing of cable; open-wire circuits and voice-frequency use; open-wire carrier circuits; program translation; Cuba-Key West cables; radio telephone; improvements in wire insulation; private branch exchange telephone system; new order receiving equipment.

CARRIER CURRENT. Current Carrier Telephony, A. C. Timmis. *Instn. Post Office Elec. Engrs.—Paper*, no. 131, for mtg. Feb. 11, 1930, 47 pp., 23 figs. Carrier telephony over transmission lines with particular reference to lines used primarily for ordinary telephone circuits; general principles; transmission; present state of art in various countries; future development.

INDUCTIVE INTERFERENCE. Foreign Systems Co-ordination Committee Reports. *Elec. West*, vol. 6, May 15, 1931, pp. 342-360, 23 figs. Report of Pacific Coast Electric Association on inductive coordination of Hoover Dam transmission line; Serjdetour telephone protector; power company telephone line protection; tests on soldered sleeve joints in telephone line construction; sleeve rolling tool and single tube sleeve; remote alarms over telephone circuits; radio coordination; common neutral.

Inductive Coordination Laboratory, E. L. Fisher. *Bell Laboratories Rec.*, vol. 9, no. 10, June 1931, pp. 481-485, 7 figs. To study under fully controlled conditions some of various effects of voltages induced in telephone lines by disturbances in neighboring power circuits, assembly of equipment has been made in laboratories.

LONG DISTANCE—TOLL SYSTEM. Standard Switching Plan for Telephone Toll Service, H. S. Osborne. *Commercial Standards Monthly*, vol. 7, no. 11, May 1931, pp. 351-352. Efficiency increased through improved coordination in planning, designing, and arrangement of toll plant; general plant described as comprehensive countrywide network of toll circuit facilities connecting important switching offices over which practically all traffic, not handled by direct circuits, will be routed.

Teletypes

The Engineering and Traffic Aspects of Teleprinter Development, A. P. Ogilvie and F. W. Dopson. *Telegraph and Telephone Jl.*, vol. 17, no. 194, May 1931, pp. 176-178, 7 figs. Type of apparatus that is being installed and general effect of its adoption on telegraph service as whole. Before Telephone and Telegraph Soc., Lond.

Testing

HIGH TENSION LINES. Fault Currents on 110-kv. Line Checked by Service Tests, L. M. Robertson. *Elec. West*, vol. 66, no. 5, May 1, 1931, p. 235, 2 figs. Measuring false currents, potential gradients, and telephone interference on its new 110-kv. wood-pole, H-frame transmission line of Public Service Co. of Colorado, are described; two types of structures were tested, one, with all insular and crossarm hardware bonded and grounded and connected to overhead wire, other type made full use of wood for insulation.

Transients

HIGH TENSION LINES. Automatic Recording of System Disturbances, J. T. Johnson, Jr. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 335-339, 12 figs. With Osiso, records of transients on system of Alabama Power C . have been recorded automatically which showed clearly and sharply all but first cycle; Osiso was mounted on portable wooden base containing all accessories necessary for automatic operation and then used for taking hundreds of records in score of different studies.

Transmission Lines

DESIGN. Transmission Line Built Across 53 Others, F. Curtis, *Elec. West*, vol. 66, no. 7, June 1, 1931, pp. 616-617, 5 figs. Design of 62-mi. 110-kv. interconnection over 53 power lines, some of 66-kv. potential, 44 telephone lines, two trolley lines, 17 railroads, two state highways, 50-ft. water tower and seven houses between San Bernardino substation of Southern Sierras Power Co. and Los Angeles Gas and Elec. Corp., Seal Beach steam electric plant.

Welding

ARC. Research Covering Alternating Current Arc Welding, G. A. Hughes and R. C. McBridge. *Iron and Steel Engr.*, vol. 8, no. 6, June 1931, pp. 241-246, 12 figs. Possibilities of a-c. arc welding, *i. e.*: chemical analysis of metal deposited, rate of deposit, ductility, tensile strength, penetration, non-ferrous metal, electrical characteristics, and bare and coated electrodes, are investigated; test results are given.

Study of Variables the Basis of Progress in Fusion Welding, C. A. Adams. *Power*, vol. 73, no. 21, May 26, 1931, pp. 813-814, 1 fig. Research has disclosed importance of understanding effects of metallurgical, chemical, mechanical and electrical variables on art of fusion welding, and has made possible its application to power plant equipment.

CAST IRON. Cast Iron To-day, A. B. Everest. *Welding Jl.*, vol. 28, nos. 330 and 331, Mar. 1931, pp. 80-83 and Apr., pp. 102-106 and (discussion) 106-109, 15 figs. Paper is presented in belief that welding engineers to-day are becoming increasingly interested in application of their art to all engineering structures, among them castings, and therefore are interested in structure and nature of commonest metal used for cast structures. Before Instn. Welding Engrs.

ELECTRODES. A New Improved Electrode for Arc Welding Stainless Steel. *Welding Jl.*, vol. 28, no. 331, Apr. 1931, pp. 118 and 120, 5 figs. New, improved electrode for arc welding of stainless steel has been recently developed by Lincoln Research Laboratories and is now being manufactured by Lincoln Electric Co., Cleveland, Ohio.

IRON AND STEEL PLANTS. Maintenance Welding in Steel Plant is Essential, E. L. Quinn. *Welding*, vol. 2, no. 5, May 1931, pp. 320-324 and 331. Application of thermit, electric arc and oxyacetylene welding to various types of repair work; procedure in welding of steel, cast iron, bronze welding of cast iron; surface hardening alloys; qualification of operators.

PIPE LINES. Progress in Arc Welded Construction of Oil Pipe Lines, J. F. Lincoln. *Oil Weekly*, vol. 61, no. 8, May 8, 1931, pp. 67-68, 72 and 76, 10 figs. Review of development in 1930; physical properties of welded joints; resistance to corrosion; ductility; welding procedure; tacking; rolling welds; tie-in welds; speed of welding; equipment; oil-carrying pip lines welded by new shielded arc process; 1010 mi. of pipe line containing 106,885 joints fabricated or now under construction.

PRESSURE VESSELS. Electric Welding Applications to Steam Pressure Vessels. *Power Plant Eng.*, vol. 35, no. 12, June 15, 1931, pp. 667, 4 figs. Electric welding of steam piping and directly fired steam drums has now passed experimental stage of development and during past year and half number of noteworthy applications have been made in power plant field; review of outstanding applications.

UNITED STATES. Some Achievements in Arc Welding in the United States During 1930, L. D. Meeker. *Sheet Metal Industries*, vol. 5, no. 1, May 1931, pp. 49-50. Welded steel structures built in 1930; automatic welding machines; atomic-hydrogen welding.

Welds

TESTING. Testing Butt Welds by Magnetic Methods, T. R. Watts. *Elec. Jl.*, vol. 28, no. 6, June 1931, pp. 389-391, 6 figs. In magnetic testing of butt welds in steel, faults are detected because of their higher reluctanc ; means of detecting regions of abnormally high reluctance, that is, faults, may be classified as "magnetrographic inspection" and measurements of leakage flux by means of weld-test meters.

Industrial Notes

American Insulators for Egypt.—The Ohio Brass Company, of Mansfield, Ohio has received a third order for insulators and transmission line hardware to be used in connection with the extensive electrification projects of the Egyptian government, now nearing completion in the Nile Valley. This most recent order for suspension insulators and hardware fittings amounts to approximately $79,000 and brings the total volume of orders received during the past twelve months for this project to $250,000.

General Electric Reports Decreased Sales.—Orders received by the General Electric Company for the first six months of 1931 amounted to $141,428,978, compared with $190,313,758 for the corresponding period last year, Gerard Swope, president, announced today. Sales billed for the six months of 1931 amounted to $141,180,091.13, compared with $197,229,346.82 for the corresponding period last year.

The National Electric Products Corporation, Pittsburgh, announces the opening of its own branch at 400 Potrero Street, San Francisco, taking over the stocks and active operations for the company on the Pacific Coast. Garnett Young & Company, who have for many years represented the National Company, resigned April 8 to take effect July 15.

The Square D Company of Texas, a subsidiary of the Square D Company, Detroit, recently opened its new factory at 3111 Polk Avenue, Houston, to service the southwest's electric equipment requirements. The Square D Company of Texas was organized in 1928 to serve the southwest with special switchboards, lighting and power panelboards, special motor control and standard Diamond E material. Branches are operated in Little Rock, Ark., Dallas and Houston, Texas.

A New Safety Switch.—The Rowan Controller Company, Baltimore, manufacturer of completely oil immersed control equipment, has recently introduced a combination safety switch and magnetic contactor for use with small alternating-current motors. The equipment can be furnished up to and including 5 horsepower, 220, 440 or 550 volts. The unit is compactly built so that it occupies a minimum of wall space, and the fact that it is completely oil-immersed makes it vapor-proof, weather-proof, and dust-tight.

New Motor Starter.—The Electric Controller & Manufacturing Company, Cleveland, Ohio, announces a new line of explosion-proof motor starters, type ZS, across-the-line, providing for full voltage starting of squirrel cage motors. These starters may also be used with an automatic field switching panel for synchronous motors and for the control of the primary of slip-ring motors. An oil tank which contains the main line contactor, is equipped with a sight oil gage to indicate the oil level inside the tank. Bolted to the rear of the tank is an explosion-proof case which contains the overload relay panel and which also serves as a conduit connection box. Maintenance is greatly reduced, because the operating mechanism is always well protected against moisture and corrosion.

Recent Westinghouse Orders.—The Westinghouse Electric & Manufacturing Company announces recent orders that include a 25-kva. synchronous condenser and automatic control switching equipment for the Puget Sound Power & Light Company. An order from the Management & Engineering Corporation, of Chicago, covers eight 2,500-kva. and seven 1,667-kva. transformers to be used to increase the capacity of the Indianapolis Power & Light Company 33,000-volt load. The Commonwealth Edison Company has ordered the first alternating-current calculating board for commercial use at a cost of approximately $50,000. The board will be located at Chicago and will be used to determine system operating conditions under various loads and schemes of operation. Only two other alternating-current calculating boards are in use,— one is at the Westinghouse plant in East Pittsburgh and the other at the Massachusetts Institute of Technology, Cambridge, Mass.

Burgess Radiovisor Bridge.—The Radiovisor Division of the Burgess Battery Company, 295 Madison Ave., New York, has announced a new light-sensitive cell representing the original development of British scientists, followed by the ingenious applications by German technicians, and finally the adaptation of the cell and its circuit to American practise. The new cell or bridge consists of a tall glass tube with a three-pronged base similar in general appearance to an ordinary radio tube. Inside the bulb and supported by two heavy lead-in wires is a plate of glass on the front side of which are two interlocking comb-like electrodes of gold leaf fused in place. Covering these electrodes is a thin layer of light-sensitive enamel derived from selenium. Extreme ruggedness is claimed for the new light-sensitive device, including the capability of handling relatively heavy current. Each bridge has maximum rating of 0.15 watt for 1.5 sq. in. of sensitized surface. The bridge is rated as possessing a high ratio of dark resistance to resistance when subjected to an illumination of 10-ft. candles, and is practically independent of voltage.

Trade Literature

Transformers.—Bulletin 170, 64 pp. Describes Wagner power transformers. Wagner Electric Corporation, 6400 Plymouth Street, St. Louis.

Safety Switches.—Catalog 100-A. Describes Wadsworth safety switches and distribution panels. Wadsworth Electric & Manufacturing Company, Covington, Ky.

Transformers.—Bulletin 3006, 8 pp. Describes a new transformer for rural line service. Allis-Chalmers Manufacturing Company, Milwaukee.

Illumination. — Bulletin "Outdoor Sports Lighting," 16 pp. Includes specifications and photographs of typical installations. General Electric Company, Nela Park, Cleveland.

Motors.—Bulletin 520, 20 pp. Describes Ideal synchronous motors, 1 to 3,000 horsepower. Illustrations, application data and dimension charts are given covering the Ideal flywheel type synchronous motor (patented) and six other standard types of synchronous motors. A rather unusual method of giving dimensions is used whereby the approximate dimensions of any of the various types of motors for any horsepower and speed rating may be obtained. The Ideal Electric & Manufacturing Company, Mansfield, O.

Resistors.—Bulletin 19, 2 pp. Describes "Ribflex" vitreous enameled resistors. These resistance units consist of a metal alloy resistance ribbon, reflexed, wound on edge on a ceramic tube and banded at each end with heavy duty terminals. The entire unit is then covered with a fired-on vitreous enamel. The advantages claimed for this type of construction over any other form of tube resistor include—greater area for heat dissipation due to flat reflexed form of resistor element, wound on edge; high wattage for continuous duty; higher wattage for intermittent duty; easily assembled in associated apparatus due to individual units being available in low values of resistance; rugged terminals fitted with screws and nuts permit mounting by the terminals; classified as bare resistor under NEMA and Underwriters' rules. Ward Leonard Electric Company, Mount Vernon, N. Y.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 9

The JOURNAL of the A.I.E.E. for September 1931

O. E. Skinner, *President*
F. L. Hutchinson, *National Secretary*

Publication Committee

E. B. Meyer, *Chairman*
W. S. Gorsuch F. L. Hutchinson
W. H. Harrison H. R. Woodrow

Publication Staff

George R. Metcalfe, *Editor*
G. Ross Henninger, *Assoc. Editor*
O. A. Graef, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY — changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in Electrical Engineering are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

REPUBLICATION from Electrical Engineering of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

Electrical Engineering is indexed in Industrial Arts Index.

Printed in the United States of America. Number of copies this issue—

23,000

This Month—

Front Cover

New 132-kv. line connecting Hoover Dam with The Southern Sierras Power Company at San Bernardino (Calif.) 225 mi. distant. The Nevada-California state line runs through the white strip of desert sand in the central background.

—Photo by Avery E. Field, Riverside, Calif.

The Mokelumne Hydroelectric Project 705
By E. A. CRELLIN

Power Distribution from Mokelumne Plants 713
By E. M. WRIGHT and B. D. DEXTER

Industry's New Responsibilities 719
By A. W. ROBERTSON

Economic Loading of Generating Stations 722
By E. C. M. STAHL

The Engineer in Civic Affairs 727
By J. ALLEN JOHNSON

Series Resistance to Increase Stability 730
By R. C. BERGVALL

Calculations for Inclined Catenary 732
By B. M. PICKENS

Catenary Construction for the Cleveland Terminal 734
By N. F. CLEMENT and E. E. RICHARDS

Telephone Toll Cable Extended 736
By E. M. CALDERWOOD and D. F. SMITH

Engineering Progress—1731—1831—1931 741
By MARTIN J. INSULL

—— Turn to Next Page

Power Supply for Telegraph Service 742
By E. W. GRIFFITH

Field Tests on Circuit Breakers 744

Test Results and System Performance 745
By PHILIP SPORN and H. P. St. CLAIR

Test Results and Circuit Breaker Behavior 746
By R. M. SPURCK and H. E. STRANG

The Orient Turns to Automatic Telephones 747
By Y. K. CHOW

Radiotel phone Service is Expanding 748
By J. J. PILLIOD

Abstracts of Papers Presented at the Pacific Coast Convention 753

Electric Power in the Wood-Products Industry . . . 753
By C. E. CAREY and K. L. HOWE

Electrical Equipment for Oil-Field Operations . . . 753
By H. C. HILL and J. B. Se LEGUE

Correlation of Induction-Motor Design Factors . . . 754
By VAINO HOOVER

Tie-Line Control of Interconnected Networks . . . 754
T. E. PURCELL and C. A. POWEL

Electrical Measurements of Sound-Absorption . . . 755
By A. L. ALBERT and W. R. BULLIS

Cathode Drop in Arcs and Glow Discharges 755
By S. S. MACKEOWN

The Kindling of Electric Sparkover 756
By C. E. MAGNUSSON

Snow Surveys and Hydro-Forecasting 756
By H. P. BOARDMAN

Radio Coordination 756
By C. C. CAMPBELL and H. N. KALB

Calorimeter Measurement of Stray-Load Losses . . . 756
By G. D. FLOYD and J. R. DUNBAR

Short Items—

Riverbend Steam-Electric Generating Station 718
Stability of Transmission Lines 721
Voice Training on a Scientific Basis 752

stitute and Related Activities 757
the Editor 766
nt 767
. . . . 769
ees 771
. . . . 776
Industrial Notes 782

KANSAS CITY meeting of the A. I. E. E. South West District offers a program of attractive technical subjects, good entertainment, and profitable inspection trips. *(See pp. 757-9.)*

TO GIVE a timely résumé of technical papers presented at the recent Pacific Coast convention and also to provide opportunity for ordering copies without further delay, abstracts of those papers not already treated in ELECTRICAL ENGINEERING are included in this issue. *(See pp. 753-6.)*

POWER engineers, particularly those engaged in load-scheduling activities, may be interested in an analysis and comparison of different methods of generating station loading. *(See pp. 722-27.)*

AN EXECUTIVE of one of the leading electrical manufacturing companies gives his conception of "Industry's New Responsibilities," as related to the present business depression. *(See pp. 719-21.)*

NEW institute officers and committees for 1931-32 recently have been announced. *(See pp. 771-6.)*

JUDGING from the letters received, the Engineering Foundation series, "Has Man Benefited by Engineering Progress," has aroused considerable interest among the readers of ELECTRICAL ENGINEERING. *(See pp. 766-7.)* The second article of this group predicts further decentralization of industry. *(See p. 741.)*

A FURTHER example of ELECTRICAL ENGINEERING's policy of reflecting the effects of engineering upon human relationships may be found in a discussion on "The Engineer in Civic Affairs." *(See pp. 727-30.)* Correspondence is invited upon any phase of this all-important subject.

A PORTION of the forthcoming Faraday centennial to be held in London will be rebroadcast over the National Broadcasting Company's network. *(See p. 760.)*

The Mokelumne Hydroelectric Project

California's latest hydroelectric development activities are centered in the Mokelumne River property of the Pacific Gas and Electric Company. This project involves the complete redevelopment of the river, from water surveys to power distribution, and will make available a billion kilowatt-hours annually, ten times the output of a 1902 development on the same stream.

By
E. A. CRELLIN
Fellow A. I. E. E.
Pacific Gas and Electric Company, San Francisco

NOT OFTEN does an addition of generating equipment to an operating system involve all of the features of a complete power system, from the study of water storage and usage, all the way through generation and transmission to the step-down substations. It is this aspect of the Mokelumne River development of the Pacific Gas and Electric Company (Calif.) which seems to make it of more than passing interest. Hydroelectric features are treated in this article; a companion article (see pp. 713-718) discusses the transmission and distribution problems.

The Mokelumne River is one of the pioneer power streams of California. Its source is in Alpine County approximately 20 mi. south of Lake Tahoe at El. 9,700 whence it flows in a general southwesterly direction for some 120 mi. to a point where its waters join the San Joaquin River on their way to the Pacific Ocean through San Francisco Bay. The lower 60 mi. of the river is quite flat, lying at an elevation of less than 200 ft. above sea level.

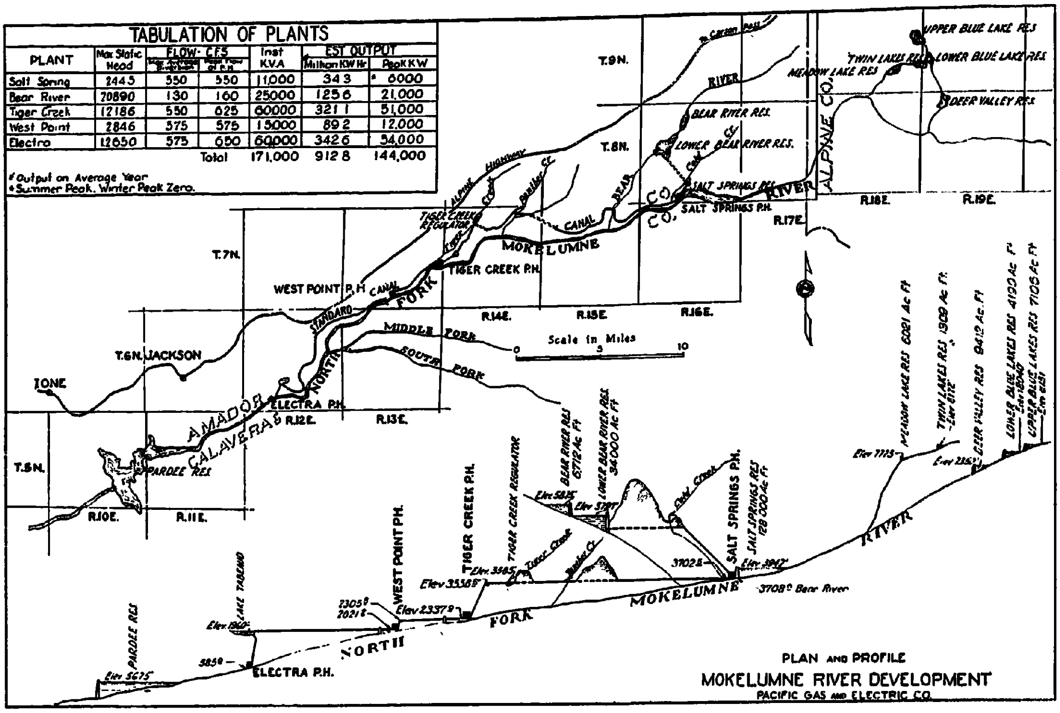
The discovery of gold and its accompanying need for water for mining operations brought about the first developments on the Mokelumne River in the fall of 1857. A company formed in that year, and its successors continued in the water supply business until the properties were acquired by the Standard Electric Company of California in the late nineties for the purpose of generating power for transmission to San Francisco, 110 mi. away. Electra power house and its associated 60-kv. transmission line were placed in service May 6, 1902, one of the pioneer hydroelectric and high-voltage transmission projects of the world. In 1907 the original installation of five 2,000-kw. units was increased by the addition of two 5,000-kw. generators; for the past 29 years the plant has been in continuous operation.

Water storage facilities on the upper reaches of the Mokelumne totaled approximately 25,000 acre-ft. divided among several small reservoirs at relatively high altitudes. This water released as needed to augment the natural flow of the river was diverted in the vicinity of the junction of Tiger Creek and the Mokelumne River into two canals (each approximately 20 mi. long and with a combined capacity of some 200 sec-ft.) for delivery into the forebays above Electra power house. The annual output of power from the system was approximately 100,000,000 kw-hr. The foregoing introductory remarks are intended to

Looking down upon Salt Springs power house from the crest of Salt Springs dam. Part of main quarry floor may be seen in right of background

---

From "The Mokelumne River Development of the Pacific Gas and Electric Company," (No. 31-130) presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, California, Aug. 25-28, 1931.



TABULATION OF PLANTS

PLANT	Max Static Head	FLOW-CFS		Inst KVA	EST OUTPUT	
		Max Average River Flow	Rated Flow of P.H.		Million KW Hr	Peak KW
Salt Spring	2445	550	550	11,000	34 3	* 6000
Bear River	70890	130	160	25000	125 6	21,000
Tiger Creek	12186	550	625	60000	321 1	51,000
West Point	2846	575	575	15000	89 2	12,000
Electra	12650	575	650	60000	342 6	54,000
			Total	171,000	912 8	144,000

Output on Average Year

* Summer Peak. Winter Peak Zero.

Plan and profile of Mokelumne River Development of the Pacific Gas and Electric Company (Calif.)

disclose the conditions existing at the time studies for the development of additional power on the Mokelumne River were begun.

Water Supply Development

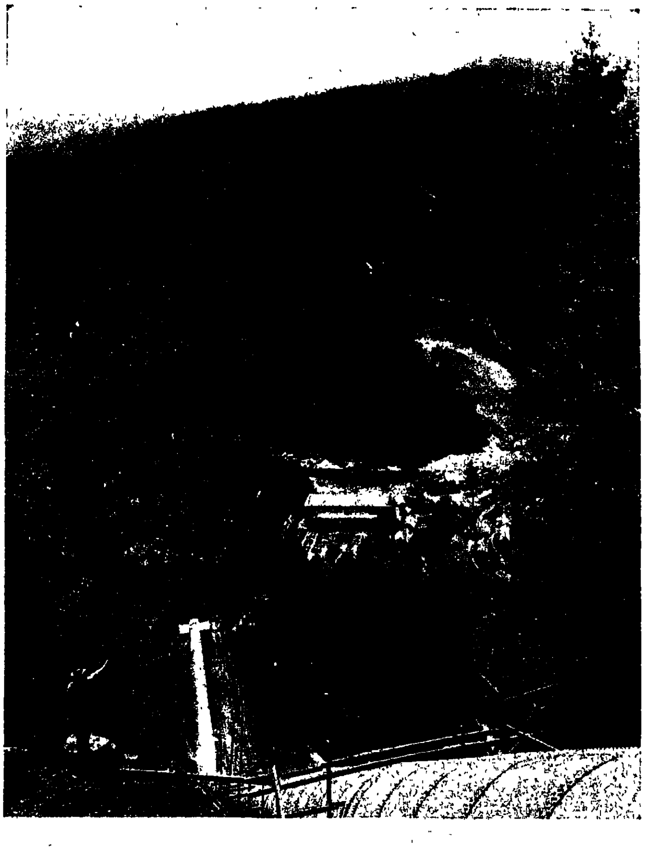
The upper portion of the Mokelumne River was relatively inaccessible and as a result, actual water record data for the upper portion of the water shed were not available. From 1906 to the present time, complete records of stream flow have been kept of readings taken at gaging stations located near the diversion into the conduits supplying water to Electra power house; and beginning with the early spring of 1924, additional gaging stations were installed at strategic locations on the upper river and certain tributary streams. The information obtained from these later stations was studied in connection with the long-time record of the original stations and runoff and storage possibilities were analyzed for 24 consecutive seasons. Runoff characteristics for the upper and lower portions of the river vary during the different months of the year. During the winter and early spring precipitation on most of the upper basin is in the form snow, while that on the lower portion of the development is rain. From the extensive water supply studies and accurate topographic maps it was possible to determine the most advantageous storage sites and to plan a comprehensive development for the most economical utilization of the water. A tabulation was prepared to show the probable use of storage water in maintaining a more or less uniformly regulated flow at the forebays of the various plants. Calculations of energy output showed that the average year would yield approximately 913,000,000 kw-hr., with 1,038,000,000 for a year of full supply and 489,000,000 for the dry-year period.

Consideration was given to the necessity of having peak output sufficient to meet system load conditions at all times, it being assumed that for dry years the peaks would be met by hydro power with steam power carrying the base load. Economic studies showed that the Mokelumne River development required back-up steam capacity of about 35 per cent of the peak, the hydro capacity representing 65 per cent of the peak. Likewise consideration was given to providing for the maximum release of stored water during the summer months (for the benefit of irrigation interests on the lower reaches of the river) which was consistent with maintaining peak demand throughout the late fall and winter. When the project is entirely completed it will involve a total water storage of some 200,000 acre-ft. and the generation of 1,000,000,000 kw-hr. annually, a tenfold increase over the original Electra development.

Two major storage reservoirs, the one on the Mokelumne River known as Salt Springs reservoir, the other on one of the principal upper tributaries and known as lower Bear River reservoir, will impound the runoff waters from their respective drainage areas. The regulation of flow in the Mokelumne River made possible by these two storage reservoirs together with the smaller reservoirs already in service, is the principal factor contributing to the increased power output. The spillway at Salt Springs dam is at El. 3,947; that of the Bear River dam at El. 5,816. The center-line elevation of the nozzles of the waterwheel units to be installed in the proposed rebuilding of Electra power house is at El. 685. Thus there is provided a total gross head of 3,262 ft. and 5,131 ft. respectively from the two main sources of storage, which head will be utilized in four steps by four power houses.

SALT SPRINGS DAM

The rock-fill dam chosen for the major Mokelumne development is believed to be one of the safest kinds of dam that can be built. (This type of dam has been very successful in California.) The canyon which is of solid granite made available at the dam site ample material for its construction. The inaccessible nature of the location necessitated the construction of approximately 50 mi. of roadway suitable for heavy trucking, and required the hauling of all materials involved over this entire distance by motor transport. The high cost of concrete materials at such a site made the estimated cost of a rock-fill dam approximately $2,000,000 less than would have been the case for a suitable concrete dam. Modern large-scale construction equipment was used on the job, including electrically operated shovels to load the rock cars and storage-battery locomotives to haul them.



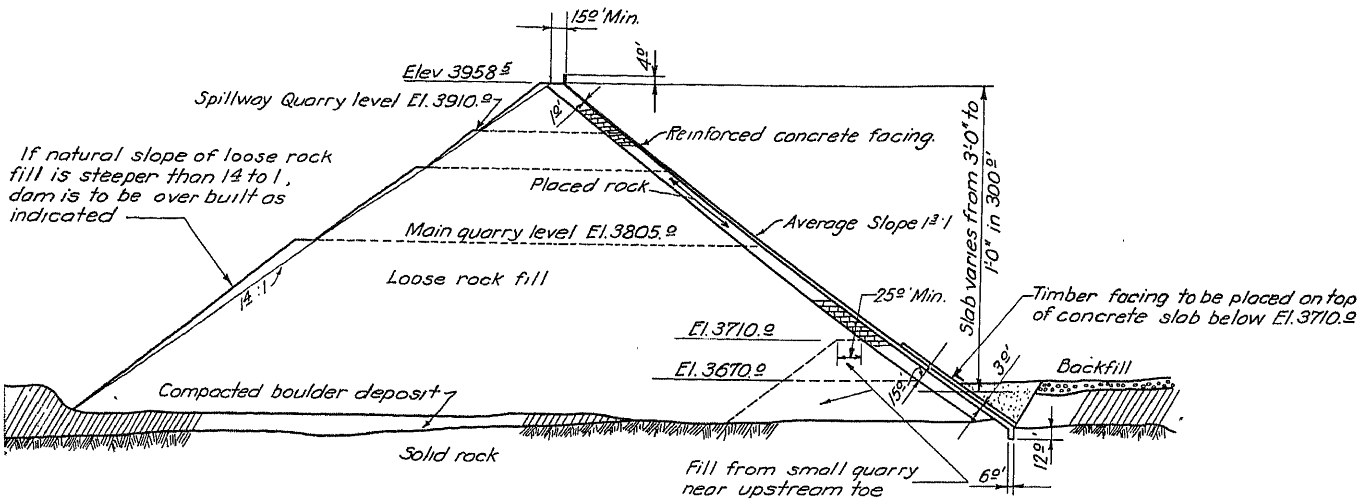
Looking down the penstock toward Tiger Creek power house. The transmission line right-of-way may be discerned on the mountains opposite

Rock for the dam was obtained from quarries at different levels near the north abutment of the dam and from the spillway excavation on the south bank. The usual quarrying methods followed featured several "big shots," each of which required in excess of 50 tons of powder and brought down approximately 200,000 cu. yd. of granite.

The dam rises 328 ft. above the stream bed, has a crest length of 1,300 ft., is 900 ft. thick at the base, and contains approximately 3,000,000 cu. yd. of material. Approximately 225,000 cu. yd. of rock were derrick-placed to a uniform thickness of 15 ft. over the entire upstream face of the dam. This placed rock forms a foundation for an outer facing of reinforced concrete which covers the entire upstream slope, varying in thickness from 36 in. at the bottom to 12 in. at the top. Concrete was placed in continuously poured 60 x 60 ft. panels of heavily reinforced concrete, each completely isolated from its neighbors by expansion or contraction joints fitted with copper water seals. The horizontal joints were poured concrete-to-concrete except for a coating of asphaltic material; vertical joints were provided with a 1-in. spacing which was filled with asphaltic compounds to permit lateral movement.

To compensate for probable settling the crest of the dam was crowned to a maximum of from 6 to 7 ft. above the theoretical crest line. To take care of down-

A typical section of concrete flume


15^{0}' Min.
4^{0}'
Elev 3958^{5}
Spillway Quarry level El. 3910.^{0}
12'
Reinforced concrete facing.
If natural slope of loose rock fill is steeper than 1^{4} to 1, dam is to be over built as indicated
Placed rock
Main quarry level El. 3805.^{0}
Average Slope 1^{3}:1
Slab varies from 3'0" to 1'0" in 300^{0}'
Loose rock fill
1^{4}:1
25^{0}' Min.
Timber facing to be placed on top of concrete slab below El. 3710.^{0}
El. 3710.^{0}
El. 3670.^{0}
3^{0}'
Backfill
15^{0}'
Compacted boulder deposit
Solid rock
Fill from small quarry near upstream toe
6^{0}'
12^{0}'

Maximum cross-section of Salt Springs dam

stream settling resulting from reservoir water pressure the upstream face was designed and constructed with an upstream convexity in plan. For similar reasons and to prevent possible buckling of the concrete face, the face was concave to the water surface in vertical section. The facing contains about 30,000 cu. yd. of concrete, has an area of about 9.2 acres, and is anchored to concrete cut-off walls extending vertically from 5 to 25 ft. into solid granite. Grout holes extend some 50 ft. below the bottom of the cut-off wall.

Salt Springs reservoir has a capacity of 130,000 acre-ft., is 4 mi. long, has a maximum width of 0.75 mi. and floods 925 acres. A spillway with a crest length of 625 ft., channeled in the south side of the gorge adjacent to the dam, has a capacity of 48,000 sec-ft., providing a capacity of 300 sec-ft. per sq. mi. of drainage area with a freeboard of 8 ft.

Outlet works at the north end of the dam consist of two 10-ft. steel pipes inserted into the downstream end of a 19-ft. concrete-lined tunnel, built originally as a diversion tunnel to facilitate construction of the dam. Each pipe is provided with a 129-in. hydraulically operated butterfly valve and then is extended on into the river channel where it ends in a 78-in. butterfly valve designed for free discharge. These valves are provided to permit unwatering the reservoir at the rate of approximately 10,000 acre-ft. per day in case of emergency, and are designed for a maximum head of 275 ft., making them the highest-head free-discharge butterfly valves yet installed.

A branch from one of these pipes forms the 8-ft. penstock to the generating unit installed in Salt Springs power house a few hundred feet downstream from the dam. A branch from the other pipe ends in a 54-in. needle valve in which is incorporated an energy absorber of the through-baffle type which discharges into the power house tailrace forming a bypass to supply water to the Tiger Creek conduit, (which heads in the tailrace) when the Salt Springs unit is shut down or when it is operating under reduced head.

Bear River Water Supply

Bear River, one of the principal tributaries of the Mokelumne River, falls at a very rapid rate from a drainage basin high in elevation, the fall in the last 6 mi. above its junction with the Mokelumne being more than 2,500 ft. A projected 200-ft. dam will form a new Bear River reservoir, adding 34,000 acre-ft. to the storage capacity. Through a tunnel approximately 2.5 mi. in length this will serve a generating unit to be placed in the Salt Springs power house. The junction of the penstock and tunnel will be formed in a surge chamber to be excavated in solid rock, with a crest elevation above high water in the projected lower Bear River reservoir just mentioned. This will permit the water from Cold Creek, (a stream adjacent and similar to Bear River but lacking in storage sites) to be diverted through this surge chamber to serve either the Salt Springs unit or for storage in the lower Bear River reservoir. Any spill from these sources may be stored in Salt Springs reservoir. The arrangement is ideal from the standpoint of ease in using the runoff from the different sources and insures complete conservation of all water resources for maximum usage.

Salt Springs Power House

Salt Springs power house will be unique in that its two generating units will be radically different in design. Two sources of water are available to this plant: the water released from storage in Salt Springs dam under a static head of 244.5 ft., and water released from storage in lower Bear River reservoir under a static head of 2,089 ft. In the first case the head and water quantities require the installation of a Francis-type turbine, while the latter can be utilized only through an impulse wheel. In general, a vertical turbine with its draft-tube setting requires a power-house floor level considerably higher above tail-water elevation than is desirable with an impulse-wheel installation; hence, to maintain the power house floor on a single level, the cooperation of the turbine builder was sought in the final designs and the unit was constructed to permit its setting at an elevation which also would accommodate the impulse wheel. Although the high-head unit will be installed at a future date considerable progress in the preliminary design of the impulse-wheel unit was required to determine with some degree of accuracy what its probable dimensions would be. This also required cooperation with the waterwheel builders. Preliminary designs were all based on the desire to secure a plant which would make for convenience in operation.

The Francis-type turbine is a vertical-shaft unit designed to pass 550 sec-ft. at heads as low as 175 ft. in order to accommodate the lowered level of water behind the dam as storage is withdrawn. In effect, to maintain full load on the generator this requires a turbine which must be operated at part gate under maximum head conditions and with gate openings increasing as the head falls. At heads less than 175 ft., water will be bypassed around the turbine into the tailrace to maintain the conduit flow at full capacity. The turbine is rated at 13,500 hp., 300 r. p. m., and drives a vertical-shaft waterwheel generator rated at 11,000 kva., 11 kv., 60 cycle, 0.85 power factor. The generator is mounted on a concrete pedestal above the turbine and is totally enclosed with surface air coolers arranged at four points around its circumference. Contrasted to this will be the horizontal shaft unit installed to utilize the water from Bear River, an overhung impulse unit capable of developing approximately 35,000 hp. at 300 r. p. m. to drive a generator having a probable rating of 30,000 kva., 11 kv., 60 cycles, 0.85 power factor.

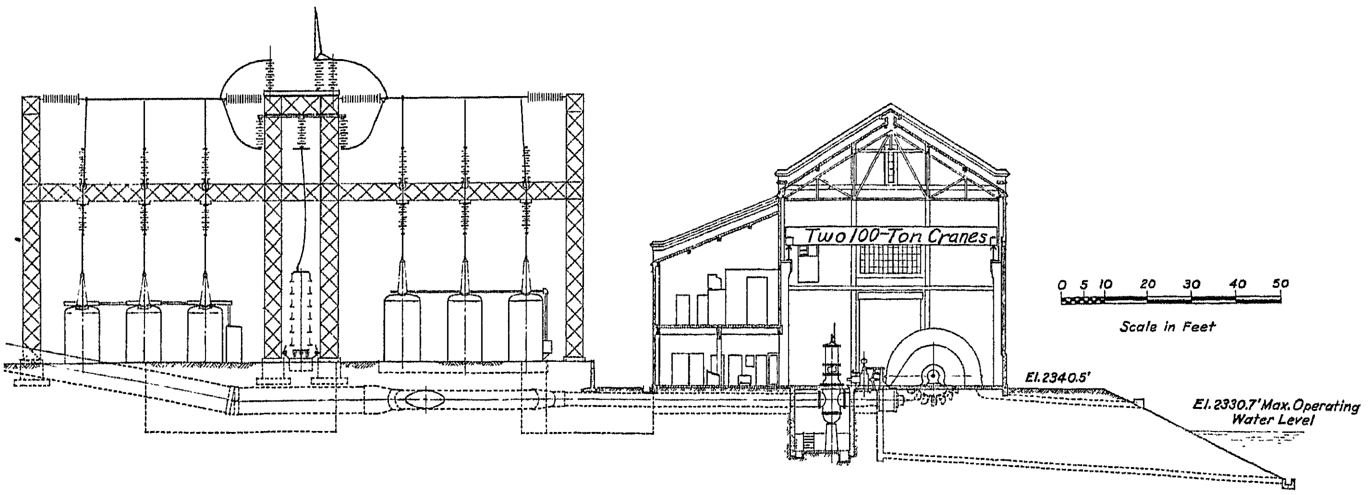
Both units will discharge into the same tailrace which forms the intake for the conduit supplying water to Tiger Creek power house. The capacity of the Tiger Creek conduit is 550 sec-ft. and it is desired to maintain this flow practically constant to supply water to Tiger Creek power house downstream. At full load the Salt Springs turbine unit will pass 550 sec-ft. and deliver power up to the 11,000-kva. rating of its generator, while the impulse unit will pass approximately 180 sec-ft. and deliver power up to the full rating of its generator, about 30,000 kva. Thus it is seen that by properly adjusting the load between the two generating units in the plant it will be possible to maintain a constant flow in the conduit at plant outputs which will vary between the limits of 11,000 kva., or less, and 37,500 kva.

At Salt Springs each generator is connected to a main bus through a single truck-type oil circuit breaker. Two similar breakers, so arranged as to be interchangeable with the main generator breakers, feed power from the main bus into the station power transformer bank. The added cost of the extra large breakers thus required for the service demands was greatly offset by the simplicity of the arrangement and the possibility of taking any oil circuit breaker out of service for inspection or repairs without any loss in plant output. From the main 11-kv. bus, leads run direct to a bank of three 12,000-kva., 11/110-kv. water-cooled transformers. A spare transformer may be substituted for any unit in the bank by means of air-break selector switches. Output from bank is fed through a 115-kv. oil circuit breaker into a single-circuit steel tower transmission line for delivery to the main 220-kv. transformer banks at Tiger Creek power house.

Tiger Creek Conduit

The 17.3-mi. Tiger Creek Conduit terminates in a regulating reservoir on Tiger Creek from which a 625-sec-ft. conduit extends 2.6 mi. to a 40-acre-ft. forebay at the head of the Tiger Creek penstock. The conduit is composed chiefly of a reinforced concrete flume with a water section of 84 sq. ft. and a water depth of 6 ft. In addition to the flume there are two 93-in. steel siphons totaling 0.23 mi. in length, and 2.5 mi. of 10 x 11.3-ft. unlined tunnel.

Topography in the vicinity of the site chosen for



Section through Tiger Creek power house parallel to penstock the Tiger Creek power house did not offer any suitable location for a forebay of sufficient capacity for the regulation of flow in the conduit and the carrying of peaks of short duration. Accordingly, a compromise was made by the creation of a pond known as the Tiger Creek regulator, about 2.6 mi. upstream from the forebay site, formed by a buttressed-slab concrete dam approximately 100 ft. high on Tiger Creek. The upper 18 ft. of the reservoir thus formed provides a storage capacity of about 175 acre-ft., sufficient to permit peaking Tiger Creek plant for 20 hr. each day when full diversion is being made into the head of the Tiger Creek conduit. About 30 min. are required for water released at the regulator to reach the forebay, and the available capacity in the forebay is sufficient to provide peaking during this interval.

Automatic gates at the outlet of the regulator reservoir maintain a constant flow in the conduit regardless of the height of water behind the gates discharging into the canal. Leads from the float controls have been carried to the switchboard room in Tiger Creek power house, enabling the operator to maintain any desired rate of flow between the regulator and forebay. The design of this automatic gate control equipment was perfected several years ago in connection with the control of water discharged from the afterbay at Pit River No. 3 power house where it has performed in every respect exactly as planned.

TIGER CREEK POWER HOUSE

The penstock consists of a single 4,750-ft. steel pipe varying in diameter from 102 in. at the top to 72 in. at the Y outside the power house. About 4,000 ft. of the upper portion of the pipe is of riveted steel with rivets countersunk on the inside of the pipe; the lower portion is seamless. At the Y the pipe branches into two 52-in. lines and again into four 36-in. lines to serve the four impulse wheels of the two double-overhung units.

Tiger Creek power house is the controlling station for the 220-kv. transmission lines constructed to receive the power generated by the waters of the Mokelumne River and to transmit it to the load centers at Newark and Herndon. To charge the 109-mi. 220-kv. line between Tiger Creek and Newark requires approximately 25,000 kva. which made desirable a minimum capacity for each generator of not less than that amount. Experience has indicated that it is much better to be able to charge a transmission line with a single unit than to attempt this function with two units in parallel. The extremely low excitation of the generator at times of charging an unloaded transmission line renders the parallel operation of generators unstable and makes their control exceedingly difficult. For this reason plant operation is very greatly facilitated if a line which is taken out of service for any reason can be charged from a single unit. Also it renders unnecessary the unloading of a second unit in order to make it available for line-charging purposes.

Static head and water quantities available at Tiger Creek indicated that the plant should have approximately 60,000 kva. in generator capacity, indicating at once that a two-unit layout was the proper one. Each waterwheel unit was designed to deliver 36,000 hp. at 225 r. p. m. under a net effective head of 1,190 ft. Generators are rated 30,000 kva., 11 kv., 60 cycles, 0.85 power factor. These waterwheel units are well up towards the maximum size practical for the head and water quantities available at Tiger Creek and in physical dimensions rank among the largest impulse wheels ever constructed.

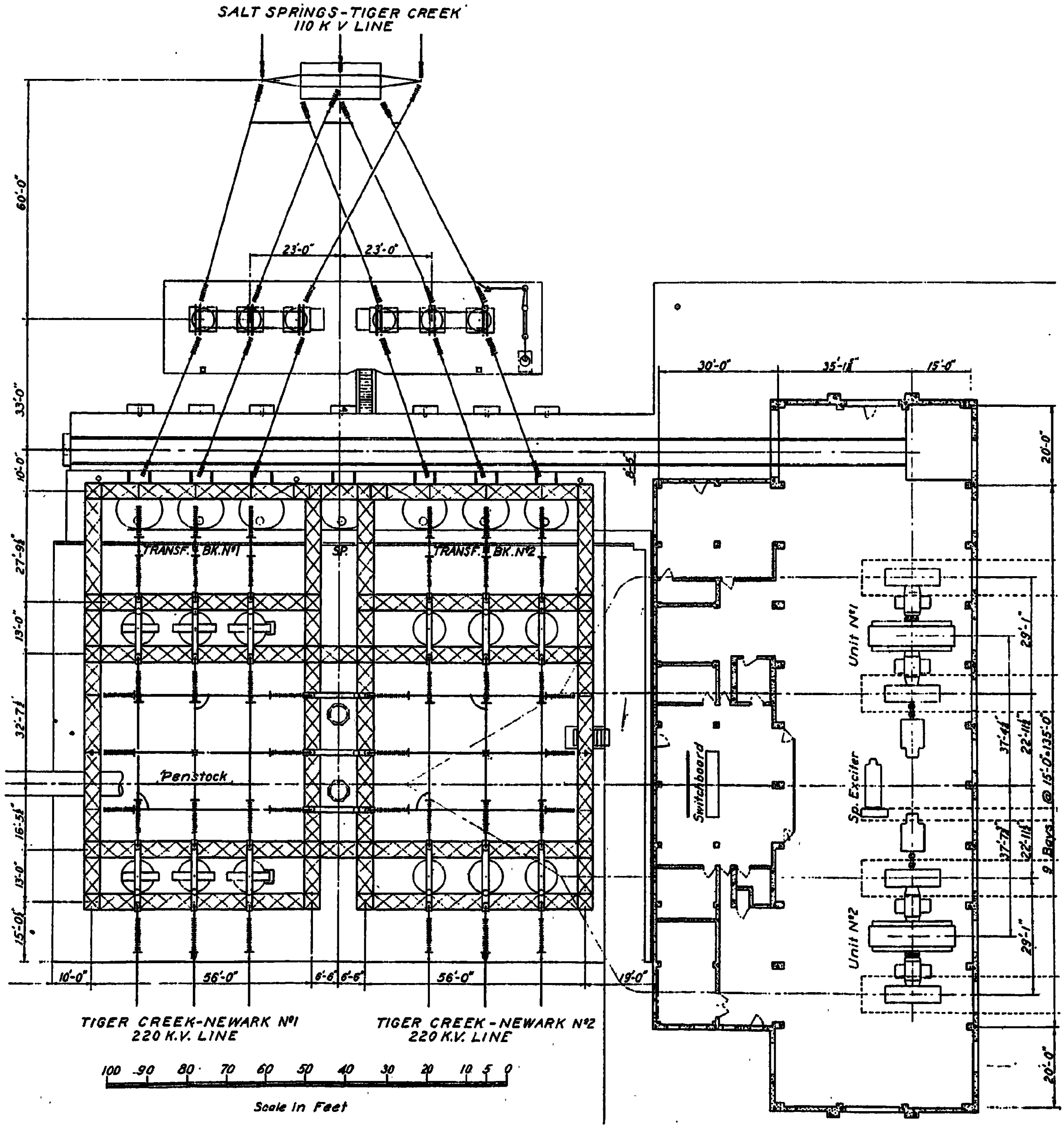
Many refinements have been incorporated in the design of the wheels. A straight-flow needle nozzle has been designed introducing into the water flow a minimum disturbance, thus giving a uniform, compact jet delivering maximum power to the waterwheel buckets. The power needles are operated by the governor servomotors and, as a water conservation measure, are arranged for slow closure upon load rejection in much the same manner that the relief valve closes on a large hydraulic turbine installation. Linked with the governor and needle-operating mechanism is a jet deflector in the form of a collar surrounding the jet which operates to remove water from the wheel instantly upon load rejection. The combination of jet deflector and slow-closing needle is ideal for an impulse-wheel installation in that it makes possible the quick diversion of water from the wheel without disturbing the flow in the penstock with its attendant surge. This permits economies in the installation through reduced penstock cost and the omission of a surge chamber.

Simplicity of plant layout was the aim throughout the design of Tiger Creek power house. Each generator with its associated step-up transformer bank is considered as a unit; there is no oil circuit breaker between the generator and the low-voltage side of the transformer. The electrical connections are extremely simple. A steel bus structure containing four 11-kv. truck-type oil circuit breakers is installed in the bus room, two of the breakers serving to connect the generators to an 11-kv. bus for the purpose of synchronizing before closing the main 220-kv. breakers. When the units are in parallel on the high-voltage side of the transformers, one of these breakers is opened separating the units on the generator side; the other remains closed to supply power for station requirements. The remaining two truck-type breakers are for the station power transformer bank. As at Salt Springs, these four breakers are interchangeable.

Each generator is provided with a direct-connected exciter and pilot exciter both controlled by voltage regulators. A spare exciter set is installed between the main generating units and arranged to be driven either by an impulse waterwheel or an induction motor. Each waterwheel has its individual governor oil pressure system with duplicate oil pumps, one motor driven and the other driven by a small impulse wheel. For normal operation the motor-driven pump maintains the oil pressure, but suitable controls have been provided so that any failure of supply from the motor-driven pump automatically will start the water-driven pump to reestablish governor oil pressure.

The switchboard is in the switch and bus section of the power house on the level of the generator floor and midway between the units. To facilitate operation all equipment requiring frequent attention has been installed on the main power house floor, and considerable thought has been given to the convenience of the location of equipment from an operating standpoint. Equipment requiring infrequent inspection has been placed on the second floor of the power house and the general layout of the plant has followed the idea of making operation possible with a normal shift consisting of a first and second operator. The duty of the first operator will be the switchboard, while the second operator will be available for oiling and operation of the disconnecting switches in the outdoor switch yard.

The two banks of step-up transformers have combined double and auto-transformer windings, each



Plan of Tiger Creek power house and bus structure

bank providing both a 30,000-kva. capacity for stepping up the incoming power from Salt Springs power house from 107.5 to 215 kv., and a 30,000-kva. tertiary capacity sufficient to care for one Tiger Creek generator. The transformer banks therefore will have a total capacity of 60,000 kva. each. A spare unit is arranged for emergency substitution in place of any of the six regular units.

To regulate water discharge from Tiger Creek plant for diversion to the next lower plant, an afterbay has been provided by constructing in the Mokelumne River some 2 mi. below the plant a concrete arch dam about 100 ft. high. This dam caused the flooding of about 100 acres, creating a reservoir of 300-acre-ft. capacity in the top 3 ft.

West Point Power House

The last of the four power houses in the Mokelumne project, but the one immediately downstream from Tiger Creek, will be known as West Point power house, the location and construction of which was influenced by the existence of the present Electra power house. Diversion of water for West Point will be made from Tiger Creek afterbay about 3 ft. from the top of the dam into a 4-mi. conduit which will connect with the West Point penstock providing a 285-ft. static head. No forebay facilities being available, the plant will be designed to operate at 100 per cent load factor with a maximum flow of 575 sec-ft. A single vertical turbine driving a 15,000-kva., 11-kv. generator will be installed and the plant will be laid out for full automatic operation, with certain controls carried back to Tiger Creek power house. Generated power will be stepped up to 60 kv. to supply the demands now served by the present Electra plant, making West Point the only plant on the Mokelumne system not regularly feeding into the 220-kv. transmission system.

Electra Power House

Construction of the new Electra power house and conduit will follow immediately upon the completion of the Salt Springs-Tiger Creek development—probably in the fall of 1931. The static head to be developed at Electra is 1,265 ft. and the water flow 575 sec-ft. The two waterwheels will have a slightly greater horsepower rating than Tiger Creek, 37,500 hp. each at 225 r. p. m., but their almost identical physical dimensions will permit the construction of a duplicate power house. One factor is present in the Electra designs which was not at Tiger Creek; the presence of an excellent 1,158-acre-ft. forebay in Lake Tabeaud. This will permit considerable peaking at Electra and all designs are being made so that a third unit for peaking may be added later.

Power generated at Electra will be stepped up through two banks of transformers to 220 kv. for connection to the Tiger Creek-Newark transmission lines. It will be necessary also to provide for supplying power to the 60-kv. and 17-kv. systems now taking the output from the present Electra plant.

General

The peak load on the system of the Pacific Gas and Electric Company and associated companies reached 853,300 kw. July 1930. In the decade 1920-1930 the load on the system has grown at the average annual rate of 7.25 per cent, requiring the addition of some 40,000 kw. of new generating capacity each year. The new capacity was provided partly in steam-driven units and partly in hydro, the ratio of the two types of prime movers for the entire system up to 1930 being approximately two to five.

Prior to the advent of natural gas as a fuel in central California, and before the recent great increased steam plant economies, hydroelectric plants with their relatively long transmission lines were able to deliver power to the consumer at prices which made the development of the hydro resources of the state economically attractive. Now the picture has changed and natural gas has placed the cost of power from the two sources approximately on a par. A relatively slight variation either way in the cost of fuel may have great influence on the type of future generating equipment.

The power peak growth of the system for the next five years will approximate 50,000 kw. annually. This is favorable to hydroelectric power in that it permits full development of a river over a short period of time, thus dividing the cost of water storage among all plants on the stream and reducing the fixed charges per kw-hr. generated. In order to produce hydroelectric power on the most economical basis, hydro plants in California must operate on the highest possible load factor. The average annual load factor for the system of the Pacific Gas and Electric Company is approximately 62 per cent and all studies for the plants on the Mokelumne River, with the exception of the 100 per cent load factor plant at West Point, were on the basis of 85 per cent load factor. Such operation will be possible in each year with normal or above normal rainfall. Studies of runoff over a 24-year period have indicated that the average annual output will be 88 per cent of the maximum possible during the wettest year recorded, with a 47 per cent output during the extreme dry year. On the Mokelumne River normal plant operation will be on base load with system peaks carried by steam. This condition may be reversed on extreme dry years when the economic use of stored water dictates its use for the carrying of peak loads.

The total cost of the Mokelumne River development as here outlined, including transmission and the increased capacity at Newark Substation, is practically $39,000,000. The entire design and construction of the project have been carried out by the regular personnel of the Pacific Gas and Electric Company.

Power Distribution from Mokelumne Plants

To carry 150,000 kw. of hydroelectric energy from the mountains of California to the San Francisco Bay area and there distribute it, required the construction of an entirely new 220-kv. transmission system and the development of a one-time 60-kv. substation into a major system switching center interconnecting 60-, 110-, and 220-kv. lines.

By
E. M. WRIGHT
Member A. I. E. E.

B. D. DEXTER
Member A. I. E. E.

Both of the
Pacific Gas and Electric
Company, San Francisco

As INDICATED in the preceding article which describes the power development features of the Mokelumne River project of the Pacific Gas & Electric Company (Calif.) one of the most unique features of the project was the fact that it required the building of practically a complete new system within a system already operating. The transmission and distribution phase of the project involved the construction of 17 mi. of 110-kv. single-circuit line to interconnect the upper two generating plants; the construction of 109 mi. of twin-circuit 220-kv. transmission line to a San Francisco Bay terminal station, the stringing of a 100-mi. 220-kv. intersystem tie line (on existing towers) and the creation of a 249,000-kva. dual terminal station providing intrasystem ties; and accommodating the two 220-kv. Mokelumne line, sixteen 110-kv. circuits, and three 60-kv. circuits.

In developing this dual substation, which is located at Newark, an unusual situation was involved. Other stations previously chosen as transmission line centers and designed with the idea of future expansion in many cases had failed to develop their expected importance due to the shifting of load centers or to changes in transmission voltage. Although not originally considered as likely to be greatly expanded, Newark station has grown through a step-by-step process (including the Mokelumne River project as a major part) into the largest and most important transmission center on the entire system. It is worthy of comment that in spite of the many additions and the changing importance of its position, the flexibility of the unit structures used has allowed it to develop into a rational arrangement.

As a result of an extended economics study and a review of the operating facilities involved, a nominal line voltage of 220 kv. was adopted. To facilitate future interconnection with the Vaca-Dixon substation (southern terminus of the company's 220-kv. Pit River system) the receiving voltage at Newark substation (the San Francisco Bay terminal station) was set at 200 kv. To enable the generators to operate at unity or lagging power factor and thereby require the high excitation essential for good stability, the voltage at the Tiger Creek end of the line was set at 215 kv., thus providing for charging current to be supplied from the receiving end.

TOWER DESIGN

The 220-kv. Mokelumne River transmission line starts from Tiger Creek power house switchyard at El. 2,400, terminates at Newark substation at El. 7, and in general involves two types of towers, two types of conductors, three different loading zones, and three zones of insulation.

In the heavy loading area, including the first 16 mi. of line out from Tiger Creek, there are two lines of single-circuit snow-type towers set in concrete foundations. These towers accommodate a horizontal configuration providing a 20-ft. spacing between conductors, and are designed for a loading of ½ in. of ice, and a wind loading of 6 lb. per sq. ft. at 0 deg. fahr. (Fig. 2.)

The next 11 mi. of line through the lower foot-hills are designed for a medium loading of ¼ in. of ice and a wind load of 6 lb. per sq. ft. at 0 deg. fahr. In that section of the line there are twin-circuit steel towers set in concrete foundations. These towers permit a semi-vertical configuration for both circuits, providing a 15-ft. vertical clearance between conductors, a 28-ft. horizontal separation between the top wires and the bottom wires of the two circuits, and a 38-ft. separation between the center wires. (Fig. 3–left.)

The remaining 82 mi. of line comprises the light-loading area where the design is based upon a wind load of 8 lb. per sq. ft. and 25 deg. fahr. In the upper 53 mi. section of this portion of the line, which crosses California's great central valley of the San Joaquin, the towers used are the same as in the previous 11-mi. section except that the middle conductors are not offset, the configuration being strictly vertical. The remaining 29-mi. section of line traverses a hilly country which is considered to be a fog area. In this lower section of the line the tower structures have the same steel below the crossarms as in the two-circuit structures of the previous section. With the upper tower design modified to provide a vertical separation of 18 ft.

From "Power Transmission and Distribution From the Mokelumne River Development of the Pacific Gas and Electric Company," (No. 31-131) presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, Calif., August 25-28, 1931.

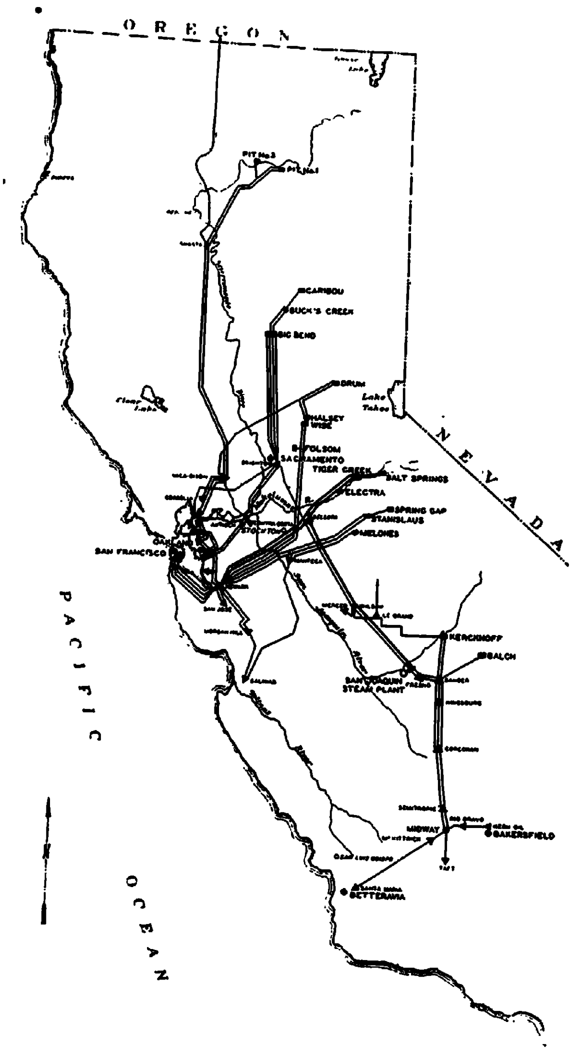


Fig. 1. Map showing the 110-, 165-, and 220-kv. transmission system of the Pacific Gas and Electric Company and the San Joaquin Light & Power Corporation

The Mokelumne circuits may be traced as the heavy lines starting at Salt Springs. The triangles indicate substations; the solid circles, major steam plants; the heavy open circles, proposed steam plants. Distances may be scaled at about 98 mi. per in. as shown

between conductors and a horizontal separation of 33 ft. between circuits. These larger spacings are used to permit the required increase in insulation. (Fig. 3-right.)

In the 17 mi. of 110-kv. line which interconnects the Salt Springs power house with the Tiger Creek power house, single-circuit snow-type towers set in concrete foundations accommodate a flat configuration of conductors providing a 14.5-ft. horizontal spacing between conductors. This line starts at El. 3,800, reaches El. 5,000 at about its midpoint, and terminates at Tiger Creek at El. 2,400.

Normal spans on the 110-kv. line are 600 ft. although there are several long spans ranging between 1,500 and 2,100 ft. On the 220-kv. main transmission line the normal span for snow-type towers is 600 ft.; for the twin-circuit towers 800 ft. Extra long spans in the 220-kv. line range from 1,000 to 1,800 ft. in length.

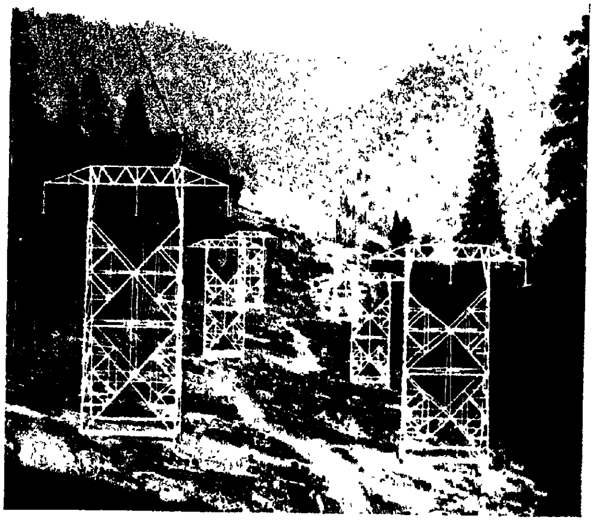


Fig. 2. 220-kv. tower line near Tiger Creek power house

Towers of the same type but of increased strength are used where necessity requires it, but no dead-ends or semi-strains are used unless required for angles, upstrains, or crossings. Transposition throughout are of the rolling type without dead-ends. (See Fig. 4.)

CONDUCTORS

As a result of extensive tests made at the Ryan laboratory, Stanford University (Calif.) two different standard types of cables were chosen for the 220-kv. line. Throughout the heavy- and medium-loading area comprising the upper 27 mi. of the line, 518,000-cir. mil steel-reinforced aluminum cable, having an outside diameter of 1 in., was selected. The stranded steel core in this cable is approximately 5/8 in. in diameter. In the lower 82-mi. section of the line where conductivity as well as corona loss were of primary importance, 500,000-cir. mil hollow-core copper conductor of 1-in. outside diameter was chosen. This cable consists of two layers of wires laid over a twisted copper I-beam.

With the aluminum cable, standard compression joints designed by the cable manufacturer were used, pressed on in the field for all splices. For the copper cable, screw joint splices were used comprising threaded lugs drawn on the end of the conductor at the factory, and connected in the field by means of a sleeve nut reverse threaded to obviate twisting the cable.

Standard bolted *J*- and *U*-bolt clamps were used on both the aluminum and copper, and both for section and dead-end construction, thus eliminating any cutting of the wires. Particular attention was paid to the choice of clamps for the aluminum conductor so that they would fit the conductor as closely as possible for not less than 80 per cent of its total circumference.

On the 17-mi. 110-kv. line above Tiger Creek plant, the normal conductor is 4/0, 7-strand medium-hard-drawn bare copper, except in some long spans where 4/0 "Hitenso" copper is used to meet strength requirements. All splices are of the drawn-joint type and were put on in the field with a portable draw-bench built for the purpose.

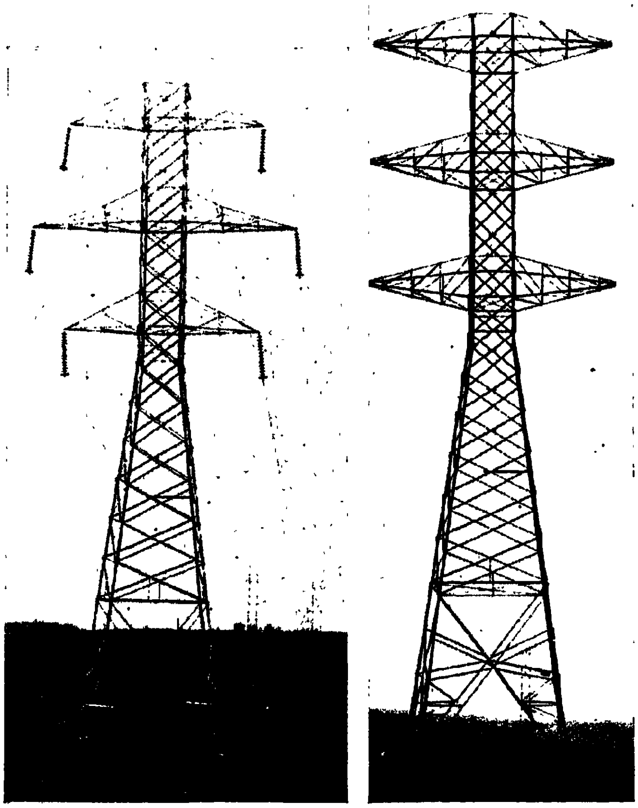


Fig. 3. Typical 220-kv. towers for medium-load area (left) and for fog area (right)

These have been reproduced approximately to scale to show the differences in relative dimensions. Careful scrutiny may reveal transposition towers in the distance (left)

INSULATION

Although ball-and-socket type insulators were used throughout on the 220-kv. transmission line, the gradations of insulation to meet local conditions divide the line in general into three sections: standard, light fog and heavy fog. The upper 79-mi. section of the line from Tiger Creek down across the San Joaquin Valley comprises the standard section, where thirteen standard-strength 10-in suspension type insulator units with 5.5-in. spacing in the suspension string, and thirteen high-strength 11-in. units with 7-in. spacing in the dead-end string, are used on both circuits.

In the two fog areas, depending upon the fog density expected, from seventeen to twenty standard insulator units are used on one circuit, and from eleven to fourteen fog-type units of two different designs are used on the other circuit. The lengths of the insulator strings of each type were laid out in proportion to the recommended insulating value. From an experimental standpoint this directly competitive insulation installation should reveal some very useful operating information as to the relative values of the standard and fog-type units under comparable and normal operating conditions.

On the 110-kv. line above Tiger Creek standard-strength suspension type insulator strings made up of eight 10-in. units were used for all suspension points, with nine units for most of the dead-ends. Where the strain was excessive such as at high points in the line, high-strength insulators in strings of nine 11-in. units were used.

BELLOTA-SAN JOAQUIN TIE LINE

At Bellota substation which is situated at a point about 42 mi. from the Tiger Creek plant, the 220-kv. Mokelumne lines cross the Feather River line. There both of the 220-kv. Mokelumne circuits are tapped to provide a feed into a single circuit which was strung about 100 mi. on the No. 2 position of the existing 165-kv. line connecting with the San Joaquin Light and Power Corporation's substation near Fresno.

The conductor used for this tie line is hollow-core copper of the same specification as that used on the

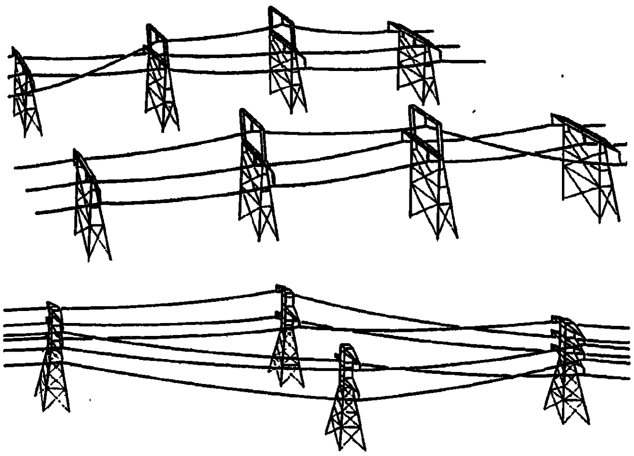


Fig. 4. 220-kv. transposition schemes

Mokelumne circuit. Insulation also is typical of Mokelumne specifications comprising fourteen standard units in suspension and fourteen high-strength units in dead-end string. A combined static shield and arcing ring is used on each insulator string. All of the switching at the Bellota substation will be handled by remote control from Stockton substation about 20 mi. away.

NEWARK SUBSTATION

Newark substation, the San Francisco Bay terminus of the Mokelumne transmission system, long has been the distributing point of Mokelumne River power (originally from Electra plant). However, growth to its present proportions was not expected when it was developed in 1919 as an ordinary 60-kv. switching and power distributing station. Nevertheless, as a result of the unit type of structure adopted in the original design of Newark station it has been possible to evolve a continuously modern station capable of handling the ever-increasing power concentration thrust upon it. With the advent of 150,000 kw. from the Mokelumne River development the principal of a dual station has been developed.

That an economical and yet flexible switching arrangement might be provided for handling the 220-kv. circuits, a double bus is used with bus selector air switches and a single oil circuit breaker for each transmission line, and transformer bank. With this arrangement a circuit can be connected to both buses, or to either bus, as switching requirements may dictate. The 220-kv. bus structure provides switching facilities for the operation of two transmission lines, three transformer banks, a bus-paralleling oil circuit breaker, and carrier-current telephone coupling equipment.

General dimensions of the bus structure are: length 354 ft., width 116 ft., height of center dead-end frame 64 ft. The structure is of galvanized steel. This design provides for the buses and selector switches to be placed well above ground elevation. The six 650,000-cir. mil concentric-lay copper cable conductors comprising the double bus are strung in tension, dead-ended at each end of the bus structure, and supported in between on the cross frame with pillar-type insulators at each bay. (Fig. 5.)

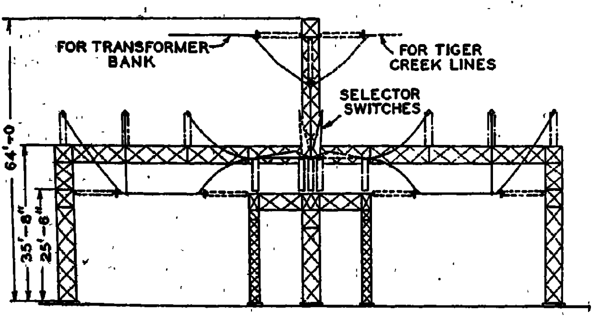


Fig. 5. Section through Newark 220-kv. bus structure

The 400-ampere selector switches are of the vertical-break type, each single-pole assembly of which consists of two single-pole air switches mounted on a common structural-steel base and insulated by five insulator posts per pole. The three poles of each selector switch are actuated by a single manually-operated control handle at the bottom of the supporting column adjacent to the switch assembly.

The two incoming 220-kv. lines and the bus tie breaker are accommodated on one side of the bus structure, while the three transformer banks are accommodated on the other side.

This arrangement of a 220-kv. oil circuit breaker complete with by-pass and disconnecting switches is similar to that employed at other 220-kv. stations of the Pacific Gas & Electric Company, (see Fig. 6) with the exception that a vertical-break by-pass switch is used instead of the so-called "roller-skate" switch previously used. Inverted switches of the latter type are used as disconnecting switches, however. On the towers which control the 220-kv. line, grounding switches are installed and mounted on the base of the by-pass switches. Grounding is effected by closing the grounding switch into a contact on the center post of the by-pass switch, subject, of course, to suitable interlock. All switches are actuated by means of rotary shafts and are hand operated. Within the galvanized tower structure is enclosed a 6-break

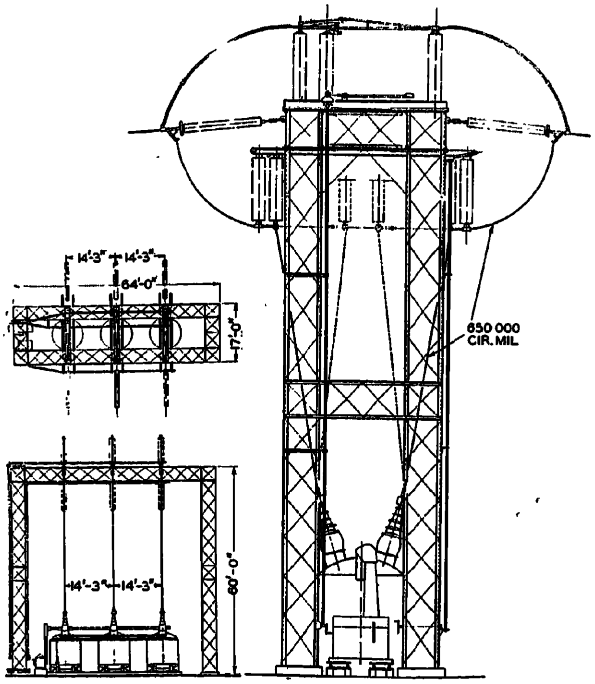


Fig. 6. Typical Newark 220-kv. self-contained switch structure

600-ampere 220-kv. oil circuit breaker mounted with the poles of the breaker on 14.25 ft. centers.

Each of the single-phase 200/110-kv. auto-transformers is rated at 18,000 kva. and is equipped with a tertiary winding to supply 11.5 kv. for synchronous condenser operation. Partial cooling is accomplished with radiators; additional cooling is obtained by means of hood-type radiator air-blast equipment. The transformer output at 110 kv. is delivered to the 110-kv. bus. One spare transformer unit is provided with a range which will permit it to be exchanged conveniently for any of the nine units in the three banks, which may require removal from service. To facilitate transformer handling a permanent handling house has been constructed and equipped with a traveling crane and all necessary tackle for untanking.

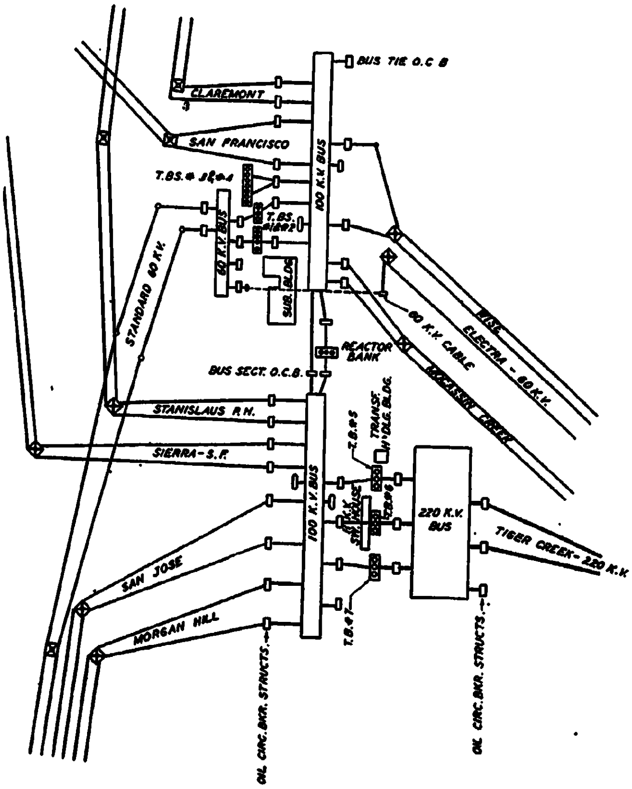


Fig. 7. General arrangement of Newark substation

Although it has developed far beyond original expectancies, the unit-type of structures consistently used have enabled the evolution of a very orderly and logically arranged station

The 110-kv. double bus also provides the single circuit breaker and switching arrangement described for the 220-kv. bus. The buses and selector switches are mounted on a rigid steel framework with all live parts well isolated by elevation. The bus conductors consist of 2-in. outside diameter, 14-gage copper tubing. Both the bus and the selector switch insulators are pillars made up of two 4-part units per post, each unit being 20 in. high. The 110-kv. bus is divided into two sections, and provision is made for controlling twelve circuits in each section.

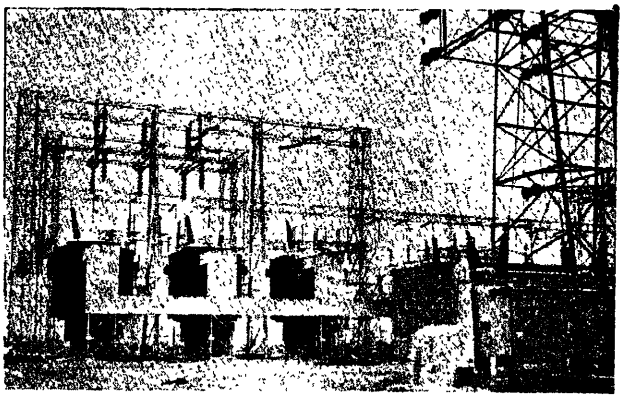


Fig. 8. Rear elevation of the 220/110/11-kv. Newark transformers

Because of the large power concentration now effected at Newark, current limiting reactors have been installed in one of the buses between the bus sections. (See Fig. 7.) Each of these single-phase 110-kv. 5,400-kva. reactor units is rated at 60 ohms reactance, and 300 amperes continuous duty, with an overload capacity of 1,060 amperes for three sec. Attention is called to the fact that this substation is essentially two stations, the dividing line being the reactor bank between the 110-kv. bus sections. One part comprises the older equipment consisting of several 110-kv. circuits, and transformer banks feeding 60-kv. circuits and synchronous condensers. The second part of the station comprises the new 220-kv. bus, together with the associated 220/110-kv. transformers, 110-kv. circuits, and related synchronous condenser equipment.

Consistent with the dual station principle it was necessary to make the switchboard in two sections, each section arranged to control its respective group of equipment. Because of the large number of circuits involved it was necessary to use a bench-board and two vertical boards, one for the indicating instruments, and one for relay equipment. To reduce the over-all length required in the switchboard, equipment for two circuits is mounted on one panel, one circuit above the other. This arrangement accomplished the necessary longitudinal reduction, but required panels 100 in. high, instead of the more conventional 90-in. boards. The entire switchboard is constructed of ⅛-in. sheet steel.

Synchronous condenser equipment for the new station consists of two 25,000-kva. 720-r.p.m. 11.5-kv. three-phase, 60-cycle machines of the totally enclosed ventilated type equipped with surface air coolers. Pedestal bearings are provided with passages for cooling water in the bearing shells. For fire-fighting water at 25 lb. per sq. in. will be used, distributed through manifolds installed at the end of the stator frame around the air gap. Each condenser is provided with a main and a subexciter. One machine was built with a 1,500-hp. synchronous driving motor to provide a convenient means of line and relay testing. This feature is particularly applicable to Newark station with its three main transformer banks, because with such grouping a bank can be released for build-up tests without great impairment of effective station capacity.

Switching equipment used in connection with the operation of the synchronous condensers is of the metal enclosed type using truck-type oil circuit breakers, and motor operated disconnecting switches. All of this equipment is housed in a small building adjacent to the 220-kv. transformers with underground lead covered cables providing the connections between switching equipment and condensers.

In unifying the existing and new control equipment in a new switchboard room the problem incident to conduit arrangements required that the transfer of control circuits from the old station to the new be made without service interruption. This was facilitated to a large extent by use of a control circuit terminal room directly beneath the switchboard room. All switchboard wires and control circuits were brought to terminal blocks and all cut-over work and testing procedure correspondingly readily executed.

Carrier-current telephone equipment installed will provide for communication over the 220-kv. lines to Tiger Creek power house, and also furnish communication circuits over the 110-kv. lines to station *J* in Oakland, whence a wire line extension is made to the load dispatcher's office. Coupling condensers on the 110-kv. and 220-kv. buses are so connected that the dispatcher may communicate directly from Oakland to Tiger Creek power house without assistance from the Newark operator.

As pointed out above, Newark substation as it now is constituted stands as the result of many additions. In spite of this, however, the flexibility of the unit structures used has allowed it to develop into a rational arrangement, and except for the old switchboard just replaced, every structure, whether installed in 1919 or in 1931, is functioning in its logical location as part of a modern substation.

In view of the fact that it is impossible to make accurate predictions as to the location of future load growth and the routing of transmission circuits to supply this load, it becomes necessary to design and construct major transmission substations in such a manner that they can be extended readily in any direction without the necessity of moving existing equipment or giving the appearance of a patched up job. Proper thought given to the design of the original installation will permit the achievement of these aims even though the station grows far in excess of any preconceived ideas as to its probable future importance. Satisfactory operation under any circumstance requires a simple and easily followed arrangement of equipment.

Riverbend Steam-Electric Generating Station

THIS newest steam station of the Duke Power Company, Charlotte, N. C., was placed in operation in October 1929 with an initial capacity of 137,500 kva., about one-fourth of the expected ultimate. Each of the two generating units operates at 1,800 r. p. m. with steam at 425 lb. gage and 725 deg. fahr., delivering energy at 13 kv. Each of the four cross-drum boilers has 35,500 sq. ft. of heating surface and is designed for 500-lb. working pressure; maximum furnace heat liberation is 30,000 B. t. u. per hr. per cu. ft. of volume. Pulverized coal is burned; the supply being received by rail. With this station the steam-electric capacity of the Duke system passed the 50-per cent point.

Industry's New Responsibilities

In an older day those who failed to store their food at harvest time did not fare so well during the winter; now, those who fail to accumulate at least a moderate surplus during times of plenty suffer accordingly during the cyclic "depressions." A thoughtful industrial leader, himself once a farm boy, here makes some interesting comparisons.

By
A. W. ROBERTSON Chairman of the Board
Associate A. I. E. E. Westinghouse E. & M. Co.

IN ITS BEGINNING this country was sparsely settled—dotted with small isolated communities tied together by waterways. Even the post roads were impassable a large part of the year. Not until 1830 did the railroads make their appearance. In 1885 the electric street car superseded the old horse cars and shortly thereafter we saw our great interurban development. The next step forward in transportation was in 1900 which marked the start of the era of the automobile. Since that time the transformation in our manner of living has been almost unbelievable.

The Passing of Individualism

It is interesting to note the shift in responsibility from the individual to industry which has taken place, even in the short space of my own life. In our early days we were tremendously individualistic. That was a basic characteristic of the founders of this nation. Every one stood on his own feet, or tried to do so, and was proud of his efforts. Each family was a group of home industries complete and almost self-supporting. Little had to be bought from the general store. Almost everything used was produced by the family. The women wove the fabrics for clothing from the wool, cotton, and hemp raised on the place. The men and boys were their own carpenters, blacksmiths, and shoemakers.

My father expected to take care of himself and his family without asking for help from anyone. He did it largely by working hard all during the spring, summer and fall. He loafed, or at least did not work so hard, during the winter. In the fall I remember we used to imitate the thrifty squirrel and stored up a supply of food to last until spring. With wood and coal in the shed, potatoes and other vegetables in the cellar, sausage, ham, and corned beef available in the meat-house, we faced the winter season of unemployment with something considerably less than dread—in fact, if I caught the spirit correctly as a boy, we really enjoyed it.

These were my personal experiences as a boy and they may not be typical of this whole country especially in the larger cities. Yet I have found them duplicated by so many other people who were reared as I was that I am inclined to think that my boyhood life represents a common picture of the independence of the individual of earlier generations. It was perhaps inevitable that this point of view should change—but it will be too bad to lose it entirely.

From Agriculture to Industry

After the Civil War in this country we commenced to be less and less an agricultural people and more and more an industrial nation. With the coming of mass production in the last thirty years, and other changes incident to it, population became congested in great cities.

Today the average home-owner has no place in which to store fuel or food beyond a supply for a short period. Gone are the days when the unit of purchase was a barrel of flour, a barrel of sugar. The unit of purchase is the smallest available package. Chain stores are conveniently located at almost every city corner and country cross-road. The railroads, trucks and passenger cars have made the distribution of goods both easy and quick, and it has been estimated that even in a large city like New York there is available less than a week's supply of food.

The average family today exists from hand to mouth and would not know how to live otherwise even if it so desired. When the periods of unemployment come, whether they be seasonal as in the older days, or due to economic depression, the average man has no fuel or food stored away to keep him and his family alive and comfortable while he searches for work to do.

If he was thrifty when business was booming, he has a savings account which he can use in bad times to buy the necessary food and clothing and keep a roof over his family. Thousands of persons have savings accounts as the statistics bear witness, yet unfortunately it just does not seem natural for human beings to be thrifty and save money while they are earning it. Certainly it does not appear that they save money now as they used to save food and fuel against the winter time of need. As a result many thousands of people today have no resources beyond their immediate needs.

From booklet published by the Westinghouse Electric & Manufacturing Company and availabl upon application to that company at 150 Broadway, New York, N. Y.

THE BURDEN OF THE IMPROVIDENT

There seems to be the growing tendency to try to shift to the shoulders of each industry the burden of providing for those improvident individuals, employed by that particular industry, who are unable to care for themselves in times of need. In certain circles apparently serious consideration is being given to the paternalistic proposals that big business, or the government, assume many of the obligations formerly recognized by the individual as his own personal burden and his own responsibility. Some states have enthusiastically adopted pension bills for mothers, for widows, and for old people; other states are giving earnest thought and study to compulsory unemployment insurance.

Meanwhile industry as a whole has voluntarily done a great deal to relieve its workmen of more and more of their former responsibilities and obligations. Most progressive companies can boast of departments which provide education, housing, a bonus, insurance, savings, old age pensions, etc., for their employees. Many companies in going into this general welfare work have taken the advanced stand, and recognized the principle that a loyal, faithful employee, in addition to his daily wage is entitled to an opportunity to participate in some form, depending upon his relative position, in the financial progress of the company for which he works.

Many companies are assuming also a large part of the cost of providing for employees during the present period of unemployment. It has become the accepted practise to spread out the available work in the plants and factories among as many men as practical although the operating results may be uneconomical for the company. These things are mentioned merely as illustrating the acceptance by industry of this added burden of unemployment.

INDUSTRY FOUNDED ON SAVINGS

The tragedy of the situation lies in the fact that big business, having assumed all these additional tasks, is just about as helpless as the employee. Every industry is affected differently by depression. Seemingly none is immune. All are influenced to the extent of having income seriously curtailed, and, in many cases, profits entirely eliminated. No company, large or small, seems to be financially strong enough, or lucky enough, to prevent serious shrinkage of its liquid resources in times of depression.

Under such circumstances the management of every company in every industry is confronted with the difficult and serious problem of deciding what course should be followed. Assuming that every well-managed company accumulated out of earnings some surplus during prosperous times, the question arises immediately as to how this surplus should be used when times are not so prosperous. The company must conduct its affairs in such a way as to maintain its credit. There must be money with which to pay honest debts—otherwise, the company will soon cease to function and it will not be able to meet any of the many obligations which it has assumed.

In addition to the creditors and the employees, there are the stockholders who have equities to be recognized. As the owners of the business, they are partners in the enterprise. Their just rights should not be ignored. Sometimes it would seem, however, from the careless talk indulged in by those who are not well informed in fact or theory, that stockholders are not entitled to any consideration. Those who voice such unsound opinions overlook the fact that stockholders, generally speaking, are employees of the company itself or are employed by some other company. At least in part, they are dependent upon their dividends just as they are on their wages for their living.

The money these people have invested in securities has to a large degree made possible the very existence of industry. The holdings of the stock of a company often represents the savings which the shareholder has made against the inevitable rainy day.

An investment is the dedication of the surplus of today to the needs of tomorrow—the insurance of ready cash to meet some form of future emergency. If that is a correct definition of an investment it may take many different forms with different people.

After a fashion, the investment by the stockholder is comparable to the stores of food and fuel which were commonly made in more primitive civilization, such as, for instance, my own boyhood days. If the rights of security-holders are not to be respected, then investors generally will cease to put their savings into industry; and there will be no industry. Further, there will be no safe place to invest one's savings.

THE HUMAN EQUATION

I fully recognize that the employees are one of the real assets of a going business—in many cases its most valuable asset—and their well being is of prime importance. People are too apt to think of big business as a piece of automatic machinery—soulless. In my opinion, the reverse is true. Big business must be human if it is going to succeed permanently because what makes the wheels go round will always be human beings—employees who are investing part or all of their life work in the service of that institution.

Business generally recognizes that regardless of the millions of money that have been put into plants and machinery, the ability to earn profits on that investment depends upon the loyalty and the efficiency of the employees.

It has been said, in substance, that public good will towards a company and its products, while intangible working capital, has as distinct earning power as the plants, which would soon turn to lifeless material were it not for the livening infleunce of these intangible values which, in the final analysis, are the contributions of the employees of a company.

The management of every concern always has before it the problem of dealing fairly with all parties involved—giving due consideration, of course, to the resources at its command. In periods of depression the task is made extremely difficult because no one can predict with any accuracy the length of time the set-back may continue. Consequently the management of a company does not know how long the earnings may continue below normal and how long it may be necessary to lend assistance to its employees out of work.

A. Mutual Problem

In the years to come if the business of this country follows the upward curve of normal progress, as it has in past decades; and, if business flourishes with only occasional periods of depression and unemployment, then the recent burdens added to industry will not become too heavy. On the other hand, if these periods of recession come too close together and increase in severity, then industry may not be able to carry on its usual normal responsibilities of payments to creditors, wages to employees, dividends to stockholders, plus the added burden of supporting the individuals who cannot provide for themselves in times of unemployment.

It would be most constructive at this time if there could be developed a more tolerant attitude toward this problem on the part of both industry and the individuals involved. The whole world is afflicted by a new set of conditions. The right cure will be beneficial to every man, woman and child; therefore, any proposal that may lead to progress in that direction should and will, I am sure, receive open-minded consideration.

To me it seems highly desirable that we keep alive the old-fashioned individualistic spirit of looking after one's self. It is going to be our salvation. It is one of our greatest inheritances from the founders of this country. After all, no one is as much interested in me as I am in myself. If each and every one of us made it our principal business to look after himself as well as a reasonably prudent man should, there would not be so much required of either industry or the state. That is what I would define as constructive selfishness.

Economic Laws are Insuperable

The picture is not without its bright side. There is ample reason to be cheerful. This country will weather this storm as it has successfully weathered every other great economic disorder of the past. And each time business has emerged upon a broader basis and a more solid foundation. The element of time is our worry. If we knew definitely when things were going to turn for the better the battle would be won and industry could plan accordingly. The rest would be easy. Certainly the worst is behind us and there is plenty of evidence for those who will look, that in certain lines, at least, improvement has commenced.

If the whole is greater than the sum total of the parts in periods of prosperity then the reverse is certainly true in times of depression. Corporations being but aggregations of people are subject to the same economic laws as individuals. Those succeed who perform or serve acceptably, and those grow more rapidly and become the greatest who serve best.

There is no Shortcut

Let us face the present unpleasant facts calmly and with courage. Let us be honest with ourselves.

There is no panacea for the present ills of all industry—no magic formula by which miracles may come to pass. Business will not change overnight, but it will be better tomorrow or the next day.

The desired objectives may be accomplished only by hard, consistent, endless work by us as individuals. There is no shortcut and we all know that is the truth.

Stability of Transmission Lines

STABILITY of power transmission "between two power plants operating in parallel is of utmost importance in providing uninterrupted power supply during system disturbances and abnormal operating conditions which may be due to short circuits, switching, and a variety of other causes," states Alexander Smouroff (F'24) professor, Electrotechnical Institute, Leningrad, U. S. S. R., in introducing a recent manuscript dealing with the subject of static stability. This paper represents another mathematical contribution to the analytical solution of the transmission stability problem and, being written by a prominent foreign engineer, represents a point of view somewhat different from that of American engineers.

The inherent dynamic stability and the artificial stability of a system are discussed, and a method is given for the determination of the dynamic stability of a system. The application of the proposed method is illustrated by practical examples.

"Stability of Transmission" by Alexander Smouroff, professor, Electrotechnical Institute, Leningrad, U. S. S. R., from which the above brief abstract has been prepared, has been placed on file (in manuscript form) for reference in the Engineering Societies Library, 29 West 39th Street, New York, N. Y. The complete manuscript is available for reference or photostat copies may be obtained from the library.

The paper concludes with an appendix in which formulas are given by which the maximum power output for stable operation of each of two plants operating in parallel may be determined as a function of the phase-displacement angle between the induced voltages of both plants. These equations give a criterion of stability and should prove of value in determinations of this character.

Economic Loading of Generating Stations

The problem of properly loading generating stations has evinced a gradual but continuous advancement as knowledge of the characteristics of power station equipment increased and methods of interpreting these progressed. The increment method has proved to be the most economical scheme thus far introduced.

By
E. C. M. STAHL
Member A. I. E. E.
Brooklyn Edison Co.
Brooklyn, N Y.

CORRECT LOADING of generating stations has assumed increased importance with interconnections becoming common, especially since the operation and control of boilers now have reached a point where dependable station heat rate characteristics can be duplicated day after day. Application of the different methods of load division, however, is dependent essentially upon the character of data available. There has been gradual development and transition in varying degrees of accuracy, from the use of average operating performance data on a monthly, weekly, or daily cost per kw-hr. basis to methods which permit of properly combining the economy characteristics of related equipment so that load can be divided on a minute-to-minute basis and full advantage taken of the immediate load conditions of the boiler room, station, or system.

With the increased grouping of stations having quite different characteristics and the rapid introduction of new types of equipment, direct and accurate means of load division must be used to secure the best operating economy. In an interconnected group, individual stations do not necessarily follow the characteristic load curves of the system demand. Consequently there is a shifting of load factors and plant factors among the different stations so that the use of average input-output data has lost much of its value from the standpoint of correct load allocation.

Briefly the steps which should be followed in setting up system-operating economies are:

1. To provide the necessary capacity in operation to insure continuity of service throughout the system.
2. To select the necessary equipment for carrying load in the order of its effect on the best *over-all* system economy.
3. To divide the load correctly on the equipment which has been placed in operation.

At least eight methods of load division have been developed, and in a number of cases the different methods, for certain ranges of operation, result in identical loading. These methods are:

1. Average increment loading.
2. Base loading.
3. Valve loading.
4. Best-point loading.
5. Proportional loading.
6. Equal-efficiency loading.
7. Increment of B. t. u. to throttle loading.
8. Increment loading.

In a system where suitable equipment and personnel are available for testing accurately each piece of equipment, information can be obtained which will permit a very accurate analysis of the load-division problem.

To arrive at the correct equipment set-up and then the correct division of load on the equipment placed in operation, the characteristics of each piece of equipment associated with power production must be known. Operating factors based upon the behavior of the equipment under normal operating conditions must be applied. Operating factors, such as the circulating-water temperature, depend partly upon conditions beyond the control of the operating personnel. In most cases, however, proper maintenance and skilful operation will result in close agreement between test and operating results. With individual characteristics known, group and station characteristics may be developed from which the final solutions may be built up.

In combination with the station characteristics, system layout and load data must be taken into account. The major factors which must be considered are: the characteristics of the daily load, load duration, and occurrence curves; local and emergency demands; local restrictive ordinances; tie-line capacities, and experience with the reliability and stability of the electrical system.

With proper equipment available and station charac-

Written especially for ELECTRICAL ENGINEERING, based upon an oral presentation before the Power Group of the New York Section, A. I. E. E., New York, April 9, 1931. Not published in pamphlet form.

teristics known, not only can a correct solution of any momentary load-division problem be reached, but studies may be projected into the future showing the probable share of load which new equipment would receive, based upon contractual characteristics. The effect of new equipment on operating costs also may be predicted quite accurately. The result of allocating any subdivision of the system load for any station may be computed, and system operating results for any proposed method may be estimated accurately. After the correctness of the station heat-rate characteristics has been established from tests and operating results, these data may be applied to the derivation of instantaneous energy costs which in turn may be used as the energy element of the cost of load transferred from one station or system to another at different periods of the day.

The different methods of load division now will be discussed in approximately the same order named previously. Fig. 1 shows station characteristics taken from daily operating data and illustrates the *average increment* method of loading. Each point represents the integrated 24-hr. output for various station loads plotted against total B. t. u. input. Over a period of time a large number of values are obtained which give the average economy characteristic trend of the station. Straight lines may be drawn through these points as indicated for stations *A* and *B*, and from this information a determination may be made as to how to load the stations with respect to each other. It is evident that if a daily output of only 100,000 kw-hr. is needed, station *A* could carry the load with less input than station *B*; if the output were 400,000 kw-hr., station *B* could carry it more economically than station *A*. If both stations were required to be in operation, station *A* would be operated at its minimum capacity until station *B* was fully loaded; and then station *A* would be loaded. This method of loading in no way takes advantage of the minute-to-minute economy relation between the stations, but merely uses the average integrated characteristics. As a result a constant increment of input is required for any added output and this constant increment represents an average increment characteristic of the station.

The method of *base loading* follows directly from the foregoing as it gives load to the best station or machine up to its maximum capacity before any load beyond its minimum requirements is assigned to the next best station or machine. Within the limits of data available both of these methods are correct, but as will be shown later they do not result in the best economy. It would appear further from a casual inspection of the heat-rate characteristics (see Fig. 6) that the *base-load* method is the correct one; but again this is not the case.

In Fig. 2 is shown a group of heat-rate curves which will be used to explain *valve opening, best-point,* and *equal-efficiency* methods of loading. Heat-rate characteristics of the older turbines are such that their best economy is obtained just before the opening of the overload valves which bypass steam into some of the lower stages of the turbine. The points at which these additional valves open are shown rather clearly in the illustration, and their effect will be fully illustrated later in showing the progress made in methods of interpreting turbine characteristics.

In the *valve opening* method when several turbines are in operation, the turbine with the lowest heat rate will be loaded first to the point where the overload valve is about to open. The other turbines then will be brought up successively to a similar condition. As the load increases still further, the best unit will be loaded up to the next valve opening, and the process repeated on the other units until full load is reached on all equipment in operation.

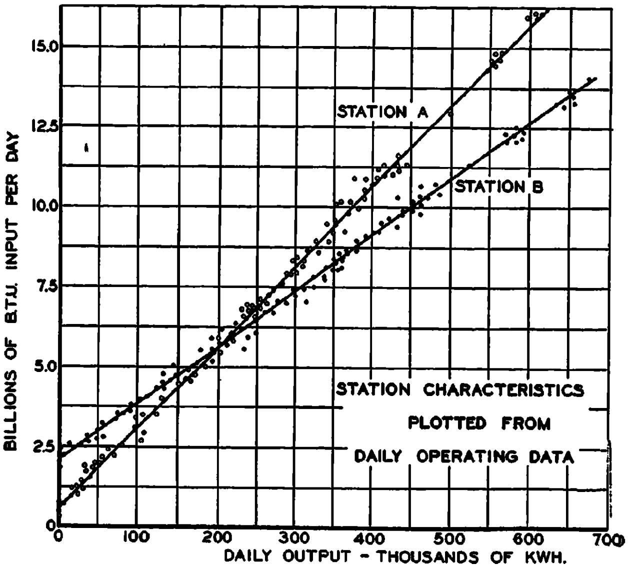


Fig. 1. Average characteristics for two typical stations as obtained from daily operating data

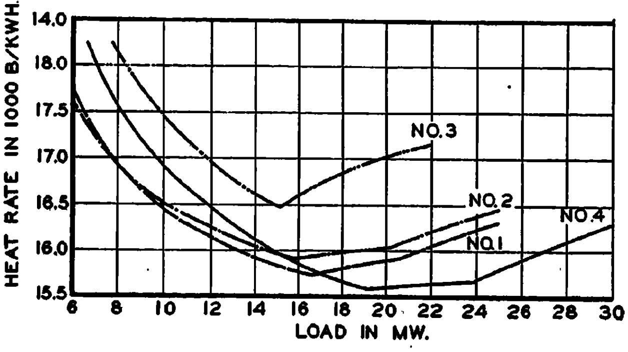


Fig. 2. Heat-rate curves for four typical turbines. Note the changing characteristics at the valve-opening points

Best-point loading in effect is quite similar to the *valve-opening* method but applies more generally to the total station heat-rate characteristics which include also the boilers. With this method, units or stations are loaded successively up to their lowest heat-rate points. In most cases, however, these coincide with the valve-opening points.

In the *equal-efficiency* method, the ratio of output to input of the various turbines must be equal, and in effect the unit heat rates also must be equal. Where this scheme is used, a schedule may be made up by maintaining equal unit heat rates on a variety of turbines, progressively as the load changes.

Fig. 3 shows a graphical layout for the method of *proportional loading.* This consists merely of plotting the sum of the turbine loads at their best heat rates and their full-load points, and connecting these points through zero with straight lines; from these, unit loads can be scaled off for any given station load.

Still another scheme is that known as the *increment of B. t. u. to the throttle* method. This is merely a special case of the incremental method, and has rather limited use where there is no bleed heating and where the characteristics between turbines are uniform.

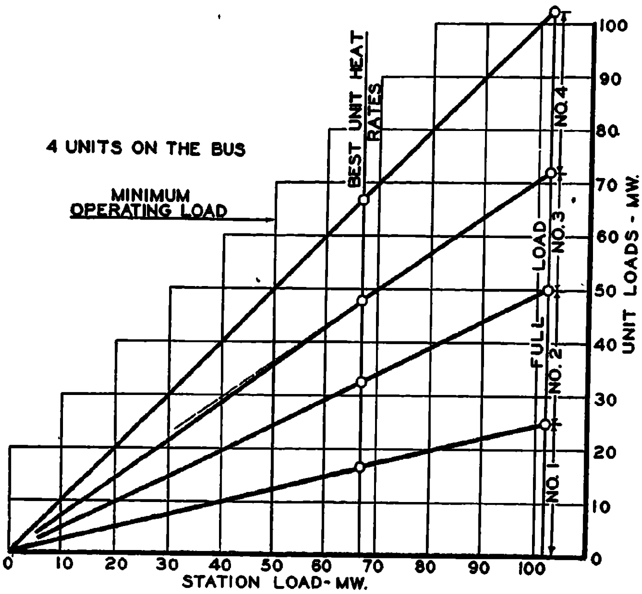


Fig. 3. Curves for establishing a proportional schedule of loading

Incremental loading, as the following discussion will bring out, results in the minimum input for any output with any given combination of equipment in operation. This method will not of itself show what equipment should be placed in operation, but with the aid of input-output data it will assist materially in determining the proper combination of equipment for various system- or station-loading characteristics.

Fig. 4 shows three stages in the chronological development of the interpretation of turbine characteristics and increment rates, the same test information being used in each case. Until about 1920 separate sets of points were plotted for the total input-output and for the unit heat rates, curves being drawn through the two sets of points independently. During the next five years the changing characteristics of the valve points were taken into consideration. As a result, the total input-output curve was drawn through the test points so that straight lines connected the test points for the separate ranges between valve openings. These lines were adjusted, however, to intersect at loads corresponding to the valve openings. The water-rate or heat-rate curves then were computed from the input-output curves.

In a more recent (1930) interpretation of test data the turbines are considered as having separate and distinct characteristics between valve openings. Entirely independent curves have been drawn through the various sets of test points between valve openings, and the unit heat rates computed from these independent sections. The corresponding incremental rates for the three schemes have been plotted and it may be noted that on the 1930 curve, the transition points have not been included on the incremental curve. From a practical standpoint this is not necessary because turbines are not operated near the valve openings,

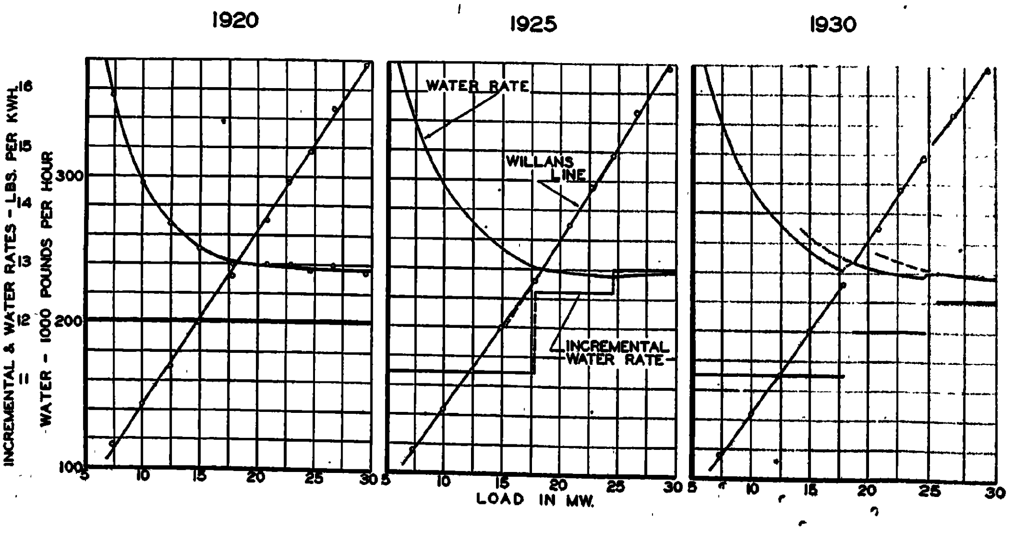


Fig. 4. Chronological development in the interpretation of turbine characteristic data

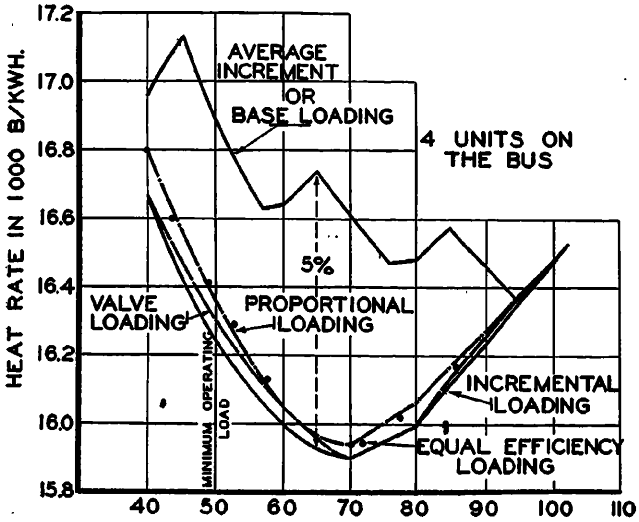


Fig. 5. Comparison of heat rates for the different methods of loading

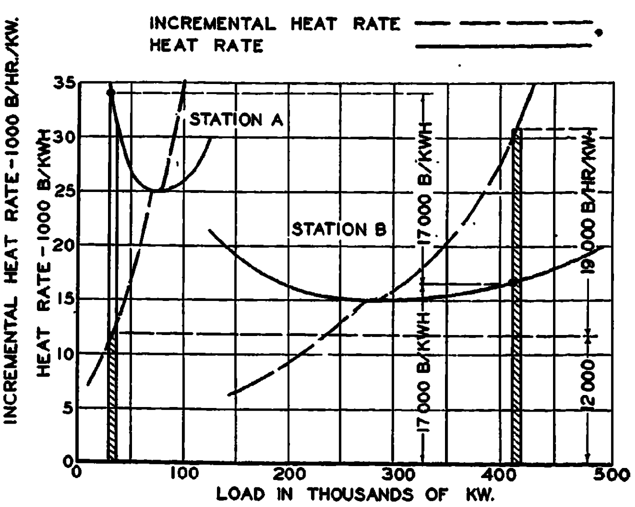


Fig. 6. Solution of typical load-division probl m by the increment method

The incremental heat rate at a given load already in production is defined as the actual additional heat per hour required to obtain the added load

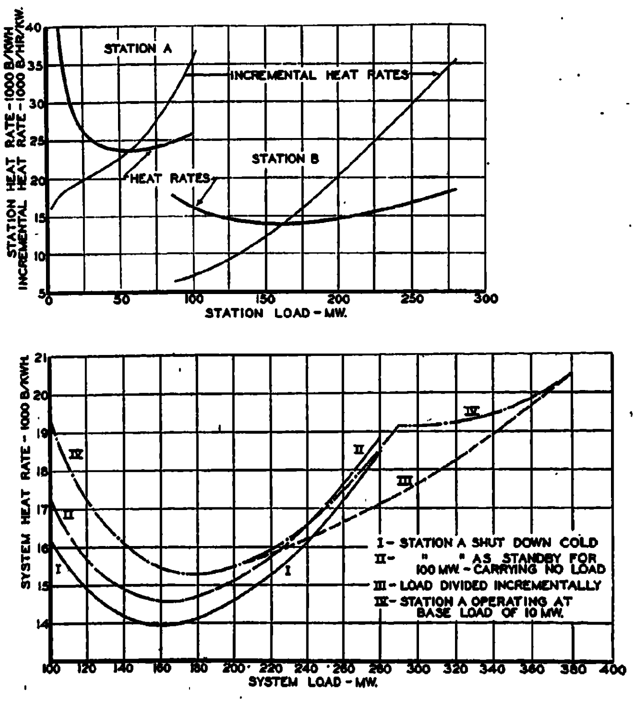


Fig. 7. Four methods of loading two interconnected stations having different heat rates

the operator passing substantially beyond those points. Again, justification for base loading of the best equipment is seen in the method used up to 1920, as a single straight input-output curve with a constant slope or increment is obtained which in itself justifies loading the best equipment or the equipment with the lowest average increment up to full load and then bringing on the next best.

A composite picture of the results of the various methods of load division is shown in Fig. 5. As would be expected the exact incremental method proves the most economical, while the average incremental or base loading method makes the poorest showing. The various other methods fall in between these two but generally nearer the exact incremental method.

The underlying principles of the incremental method are brought out by Fig. 6. Heat rates are indicated for two stations having 10,000 B. t. u. difference between their best points. Assume that the stations are so loaded that the heat rate of station *A* is exactly double that of station *B*. The question now arises as to which station should pick up the next 1,000-kw. load, assuming that the two are interconnected. From the heat-rate curves alone it would appear that station *B* should carry the additional load. It should be noted, however, that the heat rate is on the up-grade at station *B*, so that any added load would mean that its entire load would then be obtained at a higher heat rate and consequently the additional 1,000 kw. must contribute additional heat to raise the over-all heat rate of the station. On the other hand, an examination of the curves will show that the load on station *A* is such that if the added load were allotted to it, every kilowatt already in production would be obtained at a lower heat rate. At the points selected, station *A* can supply the added load to the system for 12,000 B. t. u., whereas station *B* would require 31,000 B. t. u. to produce the same load increment.

It may be noted that the dotted curves corresponding to the incremental heat rates are lower than the average heat rates while the heat rate curves are diminishing; that the incremental and average heat rates coincide where the average heat-rate curve is horizontal; and that the incremental rate is greater when the average is increasing. It can be proved mathematically and actually demonstrated that the most economical division of load is obtained when the incremental rates are equal.

As an example of a typical loading problem where two stations with different heat-rate characteristics are available, Fig. 7 illustrates the effect on system economy of operating the high-heat-rate station in different ways. Case I assumes that the best station alone is capable of carrying the entire load safely up to its full capacity, with the poorer station shut down cold. Thus if a system load up to 280,000 kw. were carried on station *B* alone, it would follow curve I. In case II it is assumed that station *A* is held with banked boilers, ready for emergency use in the event that station *B* might require emergency assistance. In this case the system heat rate would be represented by curve II. Case III goes one step farther than case II in that station *A* is maintained as a running reserve, with incremental division of load between the two stations. In this case the system heat rate would be as shown by curve III for loads above 2000,000 kw. In case IV station *A* is maintained as a running reserve as in case III, but the load between the two stations is divided by the base loading method. The system heat rate under these conditions would follow curve IV.

An interesting feature of the set of curves shown in Fig. 7 is that for loads above 240,000 kw. the system heat rate is lower with station *A* in operation than with it shut down cold. Should there be an appreciable number of kilowatt-hours to be generated at a system load higher than 240,000 kw., not only would the system be better protected by having station *A* in operation but the actual integrated heat rate would be better, as well as the instantaneous rate.

As supplementary to the foregoing discussion, the curves of Figs. 8, 9, and 10 are presented. Fig. 8 shows the heat-rate characteristics of a station with a given combination of boilers and various combinations of units in operation. For purposes of academic interest an average station heat-rate curve, such as has been used for the two previous demonstrations, is superposed on the group. Fig. 9 indicates the possible widespread variation in station heat rates, particularly of standby stations when the station plant factors and the capacity held available for emergency use are changed arbitrarily. Fig. 10 shows the general range of boiler and turbine characteristics in a large metropolitan district. The numbers opposite each curve represent the number of boilers or turbines observed to have the characteristics shown. For clarity, only a typical curve for each group has been drawn.

Basically, the problem of load division in a metropolitan area is a problem in thermodynamics. Ascertaining the principal characteristics of the equipment under operating conditions has become an extremely refined operation and is in itself a very large subject. The tremendous number of combinations of boilers and turbines which exist in any large interconnected system, the limitations imposed by the electrical system, and the ability of standby stations to be available instantly, make a complete solution extremely intricate. Instruments, however, have been developed to take care of the tremendous number of combinations once

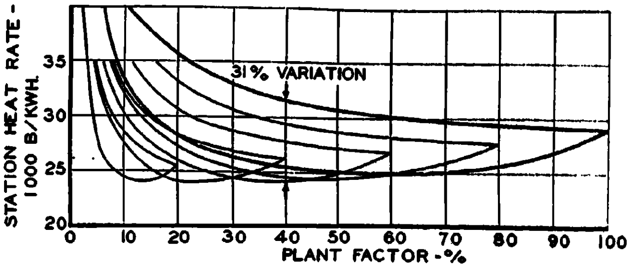


Fig. 9. Effect of peak plant capacity and load factor on station heat rate

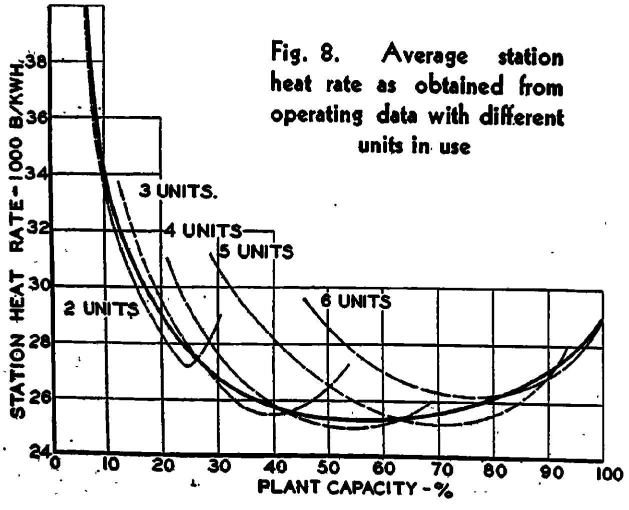


Fig. 8. Average station heat rate as obtained from operating data with different units in use

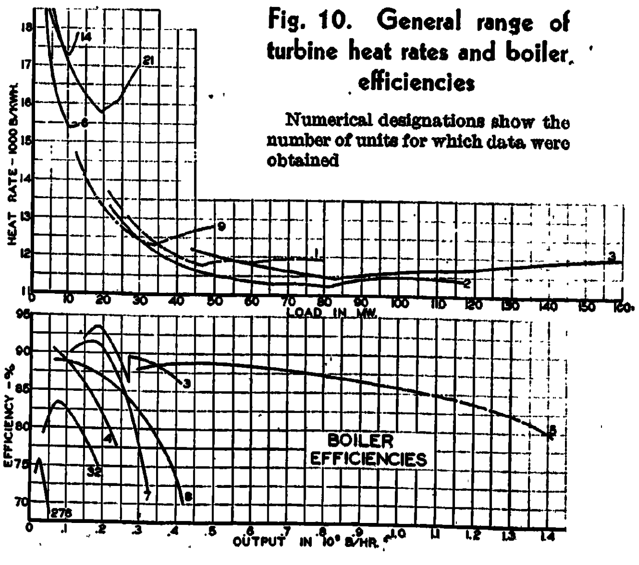


Fig. 10. General range of turbine heat rates and boiler efficiencies

Numerical designations show the number of units for which data were obtained

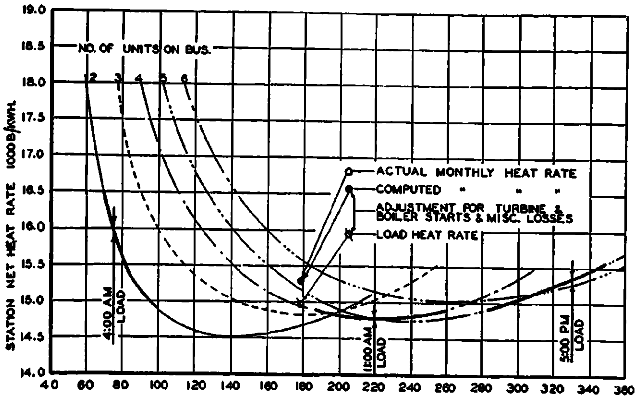


Fig. 11. Comparison between actual system monthly heat rate and computed value

the basic boiler and turbine characteristics have been determined properly.

Both the accuracy of the computations and the operation may be checked as shown in Fig. 11. This gives an illustrative group of station heat-rate curves as computed, and shows the computed monthly heat rate as compared with the actual monthly heat rate. The computed and actual rates may be seen to be practically identical.

By way of summary, the economic loading of generating stations possesses a wide variety of aspects all of which should be studied in order to arrive at a true perspective. The solution must be built up from individual equipment performance data in which the boiler characteristics play the most important part. This is particularly true when comparing two or more separate stations. It has been found also that obtaining accurate equipment characteristics has effects beyond the furnishing of data for load division and the establishing of "bogies" for operation. Manufacturers of large equipment have difficulty in checking their design practises without actual tests, and these can only be run after the equipment has been installed. Thus successive designs and guarantees may be based upon accurate information taken in the field rather than upon theoretical computation and extrapolated estimates. Furthermore, correct operating characteristics permit an estimate to be made of how well the system is being operated with respect to its possibilities, and this in turn gives assurance that no major improvement is being overlooked.

Basically, a load schedule should be set up on the assumption of unlimited tie facilities with no restrictions as to starting up or shutting down equipment. Schedules then should be set up adding successively the elements of safe operation of equipment, continuity of service, restrictive boiler-loading conditions, and tie capacity. In this way the cost of each inhibiting element may be determined. Such evaluations may be continued to take in the addition of new tie capacity, feeders, or station equipment.

The Engineer in Civic Affairs

Some of the features involved in the problem of "establishing a high professional standing of engineers in public affairs" are discussed here. Establishment of state and local engineering councils, and some means of "certification" of engineers by national professional societies are mentioned as steps toward a possible solution.

By
J. ALLEN JOHNSON Buffalo, Niagara & Eastern
Fellow A. I. E. E. Pwr. Corp., Buffalo, N. Y.

THE QUESTION of establishing and maintaining a high professional standing of engineers in civic and other similar affairs is one which requires limitation and definition to bring it within the scope of a single discussion. Three possible interpretations suggest themselves:

1. A complaint against public opinion because engineers' opinions on public questions are not given the respectful attention which engineers think they deserve.
2. A criticism of the engineering profession implying that professional standards are too low to cause engineering opinions on public matters to command public attention and respect.
3. An implication that although the profession and its standards are all right, a technique through which to make the profession authoritatively and effectively articulate on public questions is lacking.

If the first suggested interpretation were the correct one, and the effort were to devise ways and means of convincing the public that engineers should be listened to with greater respect when they deign to speak, I confess that I should have little sympathy with it. The time has passed when the professions had a monopoly on education. Nowadays an opinion on public affairs must run the gauntlet of well-informed persons in all walks of life, and must establish itself through its content rather than through its source.

Therefore, I shall assume that it is the engineering profession rather than the public which is to be scrutinized in this discussion, and that questions of both standards and methods are to be considered. In the subject thus defined there seem to be two questions involved:

1. How to establish a high professional standing of engineers.

A dissertation presented at the conference of officers, delegates, and members held at Asheville, N. C., June 22, 1931, in connection with the annual summer convention of the A. I. E. E. Not published in pamphlet form.

2. How to establish a high standing of the engineering profession in public affairs.

INDIVIDUAL IDEALS MUST BE HIGH

The attributes and responsibilities of these two aspects of professional life are well stated in an article on the "Professional Status of the Engineer" by W. E. Wickenden, president of the Case School of Applied Science (Cleveland) which appeared in the October 1930 issue of *Civil Engineering*. Dr. Wickenden states the following four attributes of individual professional life.

"1. A type of activity marked by high individual responsibility and dealing with problems on a high intellectual plane.

"2. A motive of service, as distinct from profit.

"3. A motive of self-expression which implies a joy in one's work and a single standard of workmanship; one's best.

"4. A conscious recognition of social duty to be accomplished, among other means, by: (a) sharing advances in professional knowledge; (b) guarding the standards and ideals of one's profession, and advancing it in public understanding and esteem; or (c) rendering gratuitous public service in addition to ordinary professional service, as a return for special advantages of education and status."

As a means by which individual engineers may attain a high professional standing I should recommend the conscious recognition and practise of these ideals which thoroughly express what should be the ethical and mental attitude of an engineer.

GROUP RESPONSIBILITIES

Doctor Wickenden also states the following as attributes of group professional life:

"1. A body of knowledge (science) and art (skill), held as a common possession and to be extended by united effort.

"2. An educational process of professional aims which implies a constructive share by the professional group in the ordering of education.

"3. A standard of qualifications for admission to the professional group, based on character, training, and competency.

"4. A standard of conduct in relations with clients, colleagues, and the public, based on courtesy, honor, and ethics.

"5. A recognition of status by colleagues or by organized society, as a basis of good standing.

"6. An organization of the professional group, based primarily on common interest and social duty rather than upon economic monopoly (not universal in the artistic professions)."

In addition to the obligation of the engineer to maintain a high professional standing as an individual there appears the obligation or desirability of establishing somehow this "recognition of status . . . . . by organized society" for the engineering group as a whole. Doctor Wickenden ably discussed this subject under the heading of four questions:

"1. Should we seek to divide the profession into distinct strata, or maintain an inclusive form of organization?

"2. Should we look to the public or to ourselves to set up and maintain our professional standards?

"3. Shall we narrow the doors of access to the profession?

"4. Shall we impose more rigid standards upon the colleges?"

THE MATTER OF ORGANIZATION

Under the first question would seem to come the problem of our own Institute organization. Should we have a single grade of membership or should we maintain the several grades? Much is to be said for the graded membership principle. In this country we have no aristocracy; no peerage. The result has been that for measuring one's attainments in life, no yardstick seems to be left but the financial one, a condition which I believe is largely responsible for the unfortunate American habit of measuring success entirely in terms of dollars and cents. Human beings seem to be possessed of an inherent desire to rise above the "common herd." Of those who fail to satisfy that desire by the acquisition of wealth, many seem to find satisfaction in the fraternal and social organizations with which this country is blessed (or cursed?) and get the satisfaction which they seek by attaining the distinction of election as "Kingfish of the Mystic Knights of the Sea," or perhaps as Fellows of the American Institute of Electrical Engineers. Personally, I believe that this sort of thing is a human necessity. Perhaps the field for its proper exercise is within the bounds of our professional and social organizations rather than in our civic life as a whole, but in my opinion a country which had *no means* of measuring the worth of its citizens other than by a dollar sign would be in a bad way.

Under the second question comes the matter of licensing engineers. In spite of the general opinion of engineers of high standing, that licensing is not the solution of the problem, we not only are facing, but even now are in the midst of the licensing problem. This subject already has been set forth in discussion and will not be treated here.

Under the third item again appears the question of professional society organization. Some have thought that we open our doors too wide and that higher qualifications should be required for admission to any grade of membership in a national engineering society. However, our principles and practises, as a society (A. I. E. E.) are long established in this matter and it appears doubtful that they should be changed at this late date.

Under the fourth question comes the problem of engineering education. While this problem has an important bearing on the broad question of the status of the engineer in the community, it is too large a subject to attempt to interject into this discussion.

IS CERTIFICATION THE ANSWER?

A solution of the problem of establishing for engineers "recognition of status by organized society" suggested by Doctor Wickenden is "the certification of engineers by our major professional societies." His proposal in this regard is worthy of being quoted in full. He says:

"Specifically, I should like to advocate one measure. It is in no sense a cure-all yet it would help in some degree toward the solution of each of the problems which has been discussed. This measure is the certification of engineers by our major professional societies. I would favor keeping the profession open, not making it a legal monopoly; and I would let licensing laws run their course until they find the level of their inherent limitations. I would keep our membership inclusive and not too rigidly graded, granting to engineers who pass into administrative duties the full fellowship of the profession. I should keep educational doors open to even greater variety, with a minimum of regulation and a maximum of guidance by the organized profession. All this is broad church doctrine in harmony with our history and traditions, and all good as far as it goes. But the profession needs more than an open association of like-minded men; it needs an inner nucleus of highly qualified men whose professional standing and standards the public cannot possibly mistake. A plan of certification by the profession is a task for many men to work out, not one. May I suggest, however, the following features:

"1. Certification should be earned, not granted as a mark of honor.

"2. There should be a code of educational qualifications more advanced than mere graduation from college and yet attainable by both college and non-college men.

"3. These qualifications should be tested individually, not gaged by personal estimates and testimonials alone.

"4. Educational qualifications should comprise scientific, technical, economic, and civic knowledge of a mature order.

"5. There should be a code of experience qualifications which would normally make the age of certification fall between 25 and 30.

"6. The certification of graduates should be the goal toward which the colleges and the professional societies should bend their influence. To this end the colleges should be encouraged to limit the award of professional degrees to those who previously have been certified."

Character Cannot be Inculcated by Statute

Here is a challenge to the engineering societies and the engineering profession as a whole which seems worthy of very careful consideration. It is no easy problem; the setting up of the necessary standards and qualifications for certification will be a long and difficult task, and the administration of the certification machinery after its establishment will call for men of the highest attainments and maturest judgment. And it all will cost money. If, however, the engineering profession decides that the results to be obtained will be worth the effort and cost, this seems to be a solution which would meet the desires and opinions of many of our members. I believe that its attainment, however desirable, is rather remotely in the future. Is there nothing that can be done in the meantime?

As to the licensing of engineers, doubtless some good can be accomplished if licensing laws are properly set up and administered, but as a means of separating the sheep from the goats in the engineering profession, I personally question the efficacy of inflexible statute laws. Character and ability cannot be inculcated by statute.

Is not the immediate problem that of "establishing machinery through which the opinions of competent engineers may be recognized, respected, and made effective in public affairs?"

In an attempt to answer this question, suppose we consider how we ourselves as "laymen" regard the opinions of lawyers, ministers, and others on public questions. In evaluating such an opinion, do we not subject it to critical analysis in the light of our own knowledge and judge it more by its content than by the standing of its authors? Particularly if the subject under consideration is one outside of the author's immediate specialized field.

Therefore an expression of opinion, whether by engineers or others, to be respectfully received by the public must either (1) be confined to a subject on which the author is a recognized authority, or (2) must contain within itself such evidence of breadth of view and sound judgment that it carries its own conviction.

Public Affairs Committees Suggested

Opinions by men of the engineering profession on matters of public interest rarely can be expected to fall in the first of these classes. Whence it would appear that the only way to make respected and effective the opinions of engineers on public questions is to establish some way by which such opinions can be made to bear on their faces the evidence of their own value. How can this be accomplished? How do we accomplish it in our own organization? If we wish to obtain a well considered and seasoned opinion on any engineering subject, standardization for instance, we appoint a representative committee from those best qualified to pass judgment on the matter. This committee meets, discusses, investigates, compromises, and ultimately arrives at a consensus of opinion which, when finally promulgated, is received with respect and usually accepted by the industry. If the engineering profession expects its opinions to be received with respect by the public this same method must be followed.

How, then, should such committees or groups be constituted? Obviously no one professional society can act alone in public matters; cooperation of all seems necessary. A start already has been made through the organization of The Engineering Council, a joint activity of the national engineering societies set up to deal with national affairs.

The next step in a logical development along these lines appear to be the establishment of state engineering councils to deal with engineering problems confined within state boundaries. Some action already has been taken in this direction.

Local Engineering Councils Logical

The third logical step would appear to be the formation of local engineering councils. Such councils already have been established in certain places and some of these are understood to be functioning successfully. Such local councils doubtless at first would have to be confined to the larger centers where local units of the national engineering societies exist, where they can be organized by joint action of such local groups. Possibly later on, means may be found to establish such local councils in smaller communities. To be useful to the community, such local councils should establish some sort of working arrangement with the local governing bodies.

Assuming then that the immediate solution of the problem of making the opinions of engineers respected and effective in public affairs lies in the formation of national, state, and local engineering councils, how can the A. I. E. E. promote the formation of such groups? I advance the following suggestions:

1. By gathering information on existing local and state engineering councils.
2. By establishing a standing committee to promote, oversee, and advise such local councils in cooperation with similar committee in other national societies.
3. By formulating preferred courses of local cooperation between A. I. E. E. Sections and units of other national societies for joint action in local public affairs.
4. By formulating in cooperation with the other societies a code of procedure and ethics to guide local councils.
5. By codifying successful methods of cooperation or contact between local councils and local governing bodies and assisting in establishing such contacts.

In summation, the solution of the problem of "establishing a high professional standing of engineers in civic and other affairs," may be along either or both of two lines:

1. Establishment of state and local engineering councils by joint action of the national engineering societies.
2. Establishing "an inner nucleus of highly qualified men whose professional standing and standards the public cannot possibly mistake" by some method and process of "certification of engineers by our major engineering societies."

Should the second plan ultimately be adopted, the various engineering councils might well be made up exclusively of "certified" engineers. The councils themselves, in all probability, still would be necessary, however. As an immediate step toward the desired end the formation of such councils composed of engineers of recognized high professional standing need not wait for the certification plan to be adopted.

Editor's Note: Correspondence is invited pertaining to any phase of the important subjects touched upon by Mr. Johnson. Every engineer all too soon will find himself the object and subject of inevitable legislation. For the greatest good of all concerned each individual should exert himself in cooperation with his national society to effect the necessary guidance and control of the situation.

Series Resistance To Increase Stability

As a possible method of increasing the transient stability limits of a long transmission system the author discusses the effects of inserting series resistances into the generator circuits to load the machines during fault conditions and thus retard subsequent overswings.

By
R. C. BERGVALL
Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

DEMANDS FOR CONTINUITY of power delivery from large electric stations which depend upon long transmission lines have expedited the development of high-speed circuit breakers and relays. Modern equipment will clear a fault with sequential breaker operation in from 8 to 16 cycles, depending upon the proximity of the fault to one end of the line. Because of the relatively low stored-energy-per-kilowatt factor of hydroelectric units and some steam units, even this short time, however, will not prevent loss of synchronism in many cases.

In this discussion consideration is given to the effects that may be achieved by inserting a relatively high series resistance into the generator circuit upon the advent of a short circuit. As an example for descriptive purposes, consider a short circuit to occur very close to [1] on the line [1]-[2] as shown in Fig. 1. The proposed series resistance normally would be short-circuited by circuit breaker [3]. A normal 60-cycle system is assumed; impedances as given on the diagram are based upon generator rating (kw.) and represent typical proportions. To assure that the ratio of resistance percentage to generator rating remains unchanged regardless of the number of machines in service, it is considered that resistances should be connected as shown in Fig. 2.

Upon the occurrence of a three-phase short circuit near circuit breaker [1] the generator electrical output will be decreased instantly from 100 per cent to 12 per cent of rating as a result of the low power factor in the fault-current circuit. The prime mover will continue

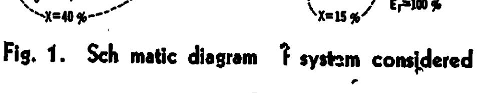


Fig. 1. Schematic diagram of system considered

From "Series Resistance Method of Increasing Transient Stability Limit," (No. 31-39) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

to apply 100 per cent torque and the difference of 88 per cent torque will accelerate the rotor. Circuit breaker [3] can be opened in from 5 to 6 cycles to insert the series resistance, and the resulting power loss will increase the generator electrical output from 12 per cent to 105 per cent until circuit breaker [1] opens after 8 cycles. A similar action takes place during the interval from 8 to 16 cycles when the fault is entirely removed from the system by the opening of circuit breaker [2]. The series resistance limits the rotor acceleration to about the same amount as would obtain if the fault were entirely removed in 5 or 6 cycles instead of in 16 cycles. This indicates the possible beneficial effects of loading the generators by inserting series resistance in the circuit during the fault period. After the fault has been cleared, the added series resistance component even though it increases the total circuit impedance exerts a substantial stabilizing influence because the stored energy of the hydro generators is less than that of the load center.

This action is shown in Figs. 3-6. Fig. 4 shows that the series resistance increases the maximum possible generator output from 147 per cent to 188 per cent of rated kilowatts. This is done at the expense of decreasing the maximum received power from 140 per cent to 92 per cent due to the loss in the series resistance. Figs. 5 and 6 show the corresponding power-angle diagrams. The shaded area in Fig. 5 shows the additional retardation area made available by the series resistance for reducing the overswing of the hydro unit. This large retarding force, acting only on the relatively low inertia of the hydro units, permits them to reach the position E_s'' (Fig. 3) instead of the position E_s' 18 cycles after a given fault, making the large gain of a_1 deg. The decreased power delivered to the load center is shown by Fig. 6, but due to the high inertia there as compared to the hydro generators a retardation of only a_2 deg. occurs. At the end of 18 cycles the total angular displacement has been decreased $a_1 - a_2$ deg. as a direct result of the insertion of 30 per cent series resistance in the generator neutral leads.

The series resistance, therefore, is beneficial in maintaining stability, both during and after a fault. Even if it is left in the circuit for a considerable time after fault clearance, the only effect will be a decrease in system frequency resulting from the added resistance loss; synchronism will be maintained.

CALCULATIONS CHECKED BY TEST

For the purpose of checking the methods of calculation used a shop test set-up of proportions similar to the hydroelectric transmission system of Fig. 1 was made. The hydro station was represented by a 100-kva. synchronous motor-generator set with the d-c. end acting as a prime mover. Sufficient external resistance was used in series with the motor armature to give it approximately constant-torque characteristics over a sufficient range of speed. The tests showed that for the same fault and time of circuit breaker operation, more than 50 per cent additional power could be delivered through the use of the series resistance without loss of synchronism.

For a system where the synchronous equipment at

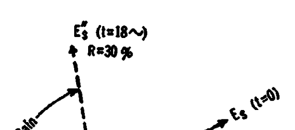


Fig. 2. Preferred location of series resistors

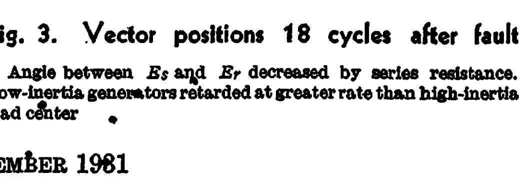


Fig. 3. Vector positions 18 cycles after fault

Angle between E_s and E_r decreased by series resistance. Low-inertia generators retarded at greater rate than high-inertia load center

Effect of 30 per cent series resistance upon system of Fig. 1 during single-line operation after fault has been cleared

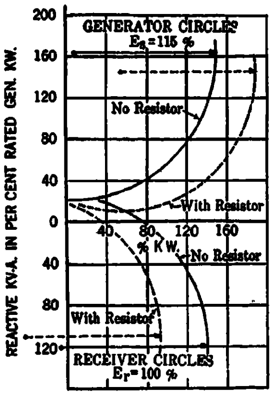


Fig. 4. Circle diagrams for single-line service

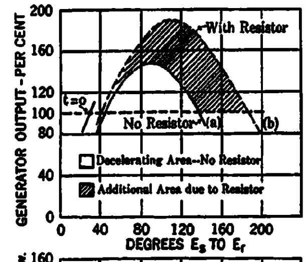


Fig. 5. Generator power-angle diagram

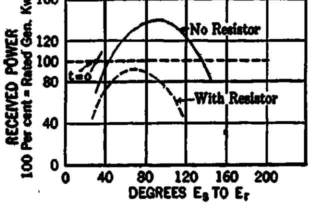


Fig. 6. Receiver power-angle diagram

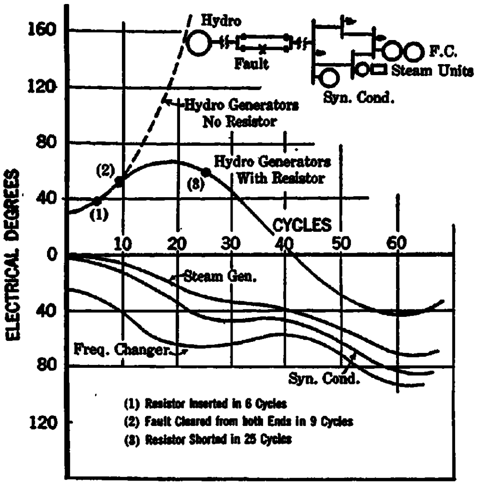


Fig. 7. Transients on typical system showing effect of series resistance

the load-end is smaller in proportion to the hydro station than usually is the case, angular oscillations obtained from a point-by-point calculation with the help of an a-c. calculating board are shown in Fig. 7. There the dotted line indicates the rapidity with which the hydro generators go out of synchronism as compared to the characteristics of the synchronous machines at the load-end, if no series resistance is inserted. The full lines show the angular oscillation with 30 per cent series resistance inserted in the circuit during the period from 6 to 25 cycles following the fault. It is evident that synchronism will be maintained, because the angular deviation has been restored to about normal within 60 cycles and the system will stabilize itself after a few oscillations. The downward slope of the curve indicates that the system frequency has decreased slightly as the result of losses occurring while the series resistance was in the circuit. The slight decrease in frequency, however, is of no consequence so long as synchronism is maintained.

The magnitude of the series resistance can be varied over a wide range with practically the same results; in any event it should be inserted as soon as possible after the fault occurs. The length of time that it is left in the circuit will depend upon the individual system under consideration. The physical size of the resistor is approximately the same as that of a corresponding neutral resistor that would be used with a generator of the rating under consideration.

CONCLUSION

As indicated, it is believed that by inserting series resistance in the circuit for a short time, synchronism can be maintained readily on a hydro system of normal proportions and for any type of fault, with the speeds of circuit breaker and relay operation now available. The cost of the series resistance and its circuit breaker in general will be less than the combination of other measures that have been used and considered in the past. Unlike most of the other measures for improving stability, the resistor installation can be deferred until operating experience indicates that the added expenditure to maintain service is justified.

Calculations for Inclined Catenary

A method is outlined whereby the vertical and horizontal projections of contact-wire hangers are computed separately and the hanger lengths in turn obtained from these. The method postulates a smooth horizontal curve of contact wire, and can be used for both regular and irregular curves.

By
B. M. PICKENS
Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

INCLINED CATENARY on curves of railway overhead contact systems is used now quite generally in the United States on systems having a single contact wire, whether simple or compound catenary. An analysis of some of the problems in the design of inclined catenary is presented here outlining a fairly simple and direct method of solving them.

Design of inclined catenary for curves is not so simple as the design of tangent catenary. On regular curves of uniform span length the hangers on each different degree of curve will have different lengths and angles, but standard hangers can easily be calculated for each different degree. On transitions from tangent to regular curves or on sections of track where the degree of curve is continually varying, a separate set of hangers must be calculated for each span.

Forces acting in the catenary system are analyzed by considering separately the vertical and horizontal projections of the wires and hangers. For a horizontal-contact wire if the vertical projection of the shortest

---

From "Inclined-Catenary Calculations,"[*] (No. 31-27) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

curve hanger is made equal to the length of the shortest tangent hanger, the vertical projection of the inclined catenary will be the same as the vertical projection of the tangent catenary for a span of the same length. Consequently, all vertical dimensions can be calculated as if dealing with tangent construction.

Horizontal dimensions can be found when the curve of the contact wire with reference to an axis between it and the messenger projection is determined (see Fig. 1). The general relationship between any three adjacent contact-wire ordinates, which determines the shape the contact wire must assume in order to be horizontal is given by the following formula:

$$t_{n-1} = t_n\,[\,2 + c/(1 + x^2/c_1)\,] - t_{n-1}$$

where $c = s\,w\,(M + T)/v_0\,T\,M$

$c_1 = 2\,v_0\,M/W$

M = messenger tension in lb.

T = contact-wire tension in lb.

W = weight of system in lb. per ft.

s = distance between hangers in ft.

w = weight of s ft. of contact wire in lb.

v_0 = vertical projection of shortest hanger in ft.

x = distance of nth hanger from center of span in ft., measured along axis.

Other relations are as shown in Fig. 2.

From this equation general shape curves can be drawn for any given catenary system. These are called the *U* and the *S* curves and are shown in Fig. 3. The *U* curve corresponds to the shape the contact wire will take on a constant radius track curve. The *S* curve corresponds to the shape the contact wire will assume on a reverse curve where the reversal occurs at the center of the span. Shapes of the contact wire for curves between these two extreme types can be found by adding together the two curves. The specific shape the wire will take on any given curve is determined by finding the correct multiplier for the *U* and *S* curves; thus a general equation may be written,

$$t = a\,U + b\,S$$

where a and b are the respective multipliers of U and S curves to satisfy the conditions of the particular curve in hand. In the case of uniform curves where the span lengths do not change, b becomes zero and a is determined by the length of span, the radius of track curve and the slope of the U curve at the support.

The contact wire must take a smooth continuous curve from span to span. Mathematically this means that the contact wire curves for two adjacent spans must have a common tangent at the support. This is one of the conditions used in the solution of the constants for the general equation of the contact-wire curve. These constants are obtained by solving simultaneously the group of equations which can be written for two adjacent spans. The data regarding the track characteristics are obtained from field measurements or track plans. In order to obtain a solution it is necessary to approximate a value for the contact wire ordinate at the third support in the two spans but it can be done by treating the section of track, at the third support, as a uniform curve. The value used will be checked automatically by the calculations for the next span. When the constants for the general equation are obtained the values for the contact wire ordinates at the various hanger locations and supports can be calculated and all the values for hanger lengths, angles and support locations are known.

The contact-wire curve may not assume the same shape as the track curve. On uniform curves it can be given practically the same shape as the track curve but this imposes certain limitations on the design that are not always desirable. The average unit stresses in the supporting and supported wires must be the same for materials of the same specific gravity. Where this design condition is not followed the contact-wire curve will depart somewhat from the track curve and must be allowed for in the design.

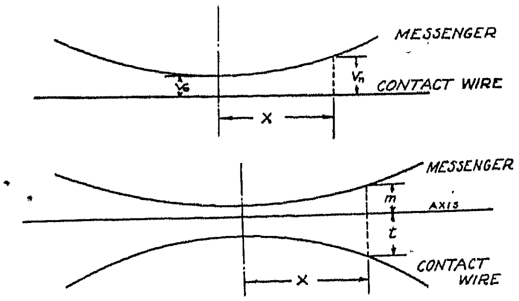


Fig. 1. Vertical (above) and horizontal (below) projections of messenger and contact wire on inclined catenary

The axis between the horizontal projections is established so that $t/m = M/T$, where M and T are the respective tensions in the messenger and contact wires

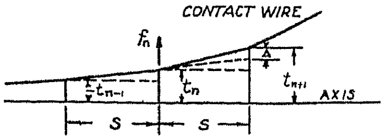


Fig. 2. Horizontal projections of three adjacent hanger locations at any place in the span

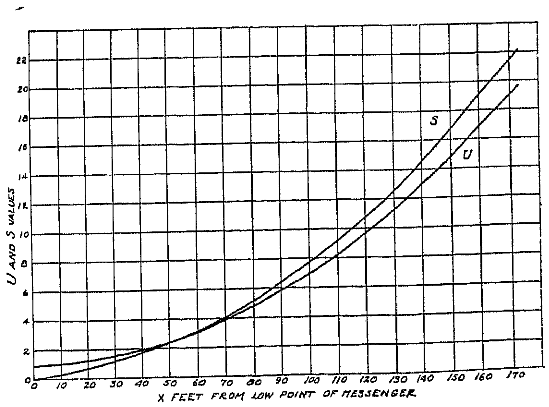


Fig. 3. "U" and "S" curves showing relative horizontal projections of hangers at different points in the span. Values for one-half of the span only are shown, the other half being symmetrical

Catenary Construction for the Cleveland Terminal

Design and construction details involved in the electrification of 59 track miles in connection with a major union terminal development are outlined.

By
N. F. CLEMENT — Associate A. I. E. E. — Formerly with The Cleveland Union Term. Co.
E. E. RICHARDS — Non-member — The Cleveland Union Terminals Company

HEAVY CURRENTS and low overhead clearances were the principal factors governing the design of the catenary system of the Cleveland Union Terminal at Cleveland, Ohio, where twenty 200-ton electric locomotives are in active service, each capable of pulling a fifteen-car pullman train up the maximum grade. Throughout the electrified system were many overhead bridges having relatively low clearance, and most of the station area is covered by buildings with an overhead clearance of but 17.5 ft.

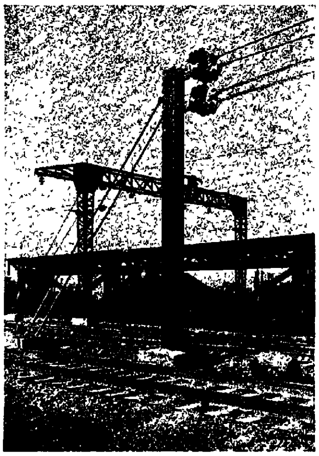
Two main tracks were electrified for a distance of 11 mi. east of the public square, where the station is located, and about 6 mi. west of the same point. Including crossovers and yard tracks, the total electrified mileage is about 59 mi. Two substations, each approximately midway between an end of the electrification and the Cleveland station, supply the catenary system with 3,000 volts direct current.

CATENARY CONSTRUCTION

The tangent chord type of construction is used, because the weighty system necessary for the carrying of heavy currents does not lend itself readily to the inclined type of construction. Except through the Cleveland station, the construction over the two main tracks consists of a primary messenger supporting by hangers a secondary or auxiliary messenger to which are clipped two 4/0 grooved bronze contact wires placed side by side. The primary messenger has a 19-wire core of high-strength bronze, and a 16-wire outer layer of copper, the total conductivity being equal to 350,000 cir. mils of copper. The auxiliary messenger is 4/0, 19-wire hard-drawn copper, and the hangers supporting it are of No. 1 hard-drawn copper wire.

For yards and crossovers the auxiliary messenger is dispensed with. The two 4/0 grooved bronze contact wires are placed one above the other, the upper one suspended by means of hangers from a 5/8-in. bronze messenger, and in turn supporting the lower one by clips.

In the station area, tandem contact wires only are used. These are 4/0 grooved bronze wires, one above the other as in yard construction, suspended in approximately 70-ft. spans. This construction was necessary to keep the line down to around 17 ft. above the rail. The main messenger and auxiliary are dead-ended on both sides of the station, and one 150,000-cir. mil cable for each main line track is carried through a duct from one dead end to the other.



Dead-end construction for two main-line catenaries. Yoke assemblies are used for the auxiliary messenger and contact wires, similar to those for the main messenger

Each main line catenary is divided electrically into five sections by four air-gaps or isolated sections. Separate feeders are run to the isolated sections, two sections being on the east and two on the west of the Cleveland station.

The maximum span on tangent track was fixed at 300 ft., giving a sag of approximately 5 ft. at 60 deg. fahr. with the assumed weights. With a 21-in. suspension assembly, a 6-in. center hanger, and an assumed 3-in. distance between the auxiliary messenger and the contact wires, it was found that structures about 7 ft. 6 in. higher than the contact wires were required. Due to the great number of low-clearance overhead street bridges it was decided to use the rather low normal contact wire height of 18 ft. 6 in. at 60 deg. fahr., thus giving a structure height of 26 ft. for a 300-ft. span.

For spacing structures on curves, charts similar to those used by the designers of the Illinois Central catenary system were made up. It was assumed that on curves the contact wire would not be allowed to be more than 12 in. from the inclined center line of the

---

From "Design of Catenary System for Cleveland Union Terminal," (No. 31-31) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

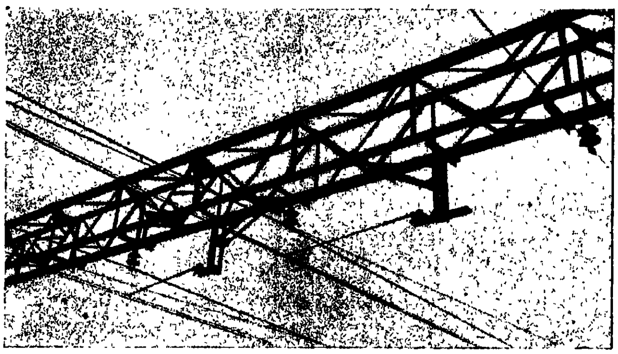
track, either at the center line of the span or at the ends, thus giving a maximum allowable middle ordinate of 2 ft. In laying out the plans, celluloid curves representing the messenger wires with dead load at 0 deg., at 60 deg., and at 120 deg. fahr. were made and used on profile paper to draw in the messenger above the contact wires. The height of all structures then could be read directly from the profile.

When approaching low-clearance overhead street bridges the line was gradually lowered so that the messenger took its natural curve under the bridge, avoiding upthrust on the suspension insulators attached to the bridge. The natural curve used in these cases was the 0-deg. curve.

The various structure heights obtained from the profile were grouped in steps varying by 6 in.; foundation depths also were varied by 6-in. steps. This expediency permitted the structures to be designed in groups varying in height by 1 ft.

SAG AND TENSION CALCULATIONS

Parabolic formulas were used in the sag and tension calculations, because the parabola of the simple curves was considered to give the closest approximation to the true curve of the messenger. The sag and tension chart was drawn for a 300-ft. span, modified slightly from the A. E. R. E. A. chart in that the load lines were made curved instead of straight, thus allowing the use of a uniform scale for sag. The decision to use a non-corrosive messenger was found to introduce large vertical movement that could not be avoided. The messenger finally selected had a sag of 46.5 in. at 0 deg., 58.5 in. at 60 deg., and 73 in. at 120 deg. fahr. for a 300-ft. span.



Steady arms are used on tangent track to brace the auxiliary messenger and contact wires

The equivalent span, using Idail's formula, was found to be 260 ft. for the main line and to range from 120 to 280 ft. for the yard lines. As it was impossible to string every yard line on a different tension basis, the yard-line values were divided into two sets, those having equivalent span lengths up to 200 ft. using 160 ft., and from 200 ft. up using 240 ft. The equivalent span for the auxiliary messenger and contact wires was 20 ft.

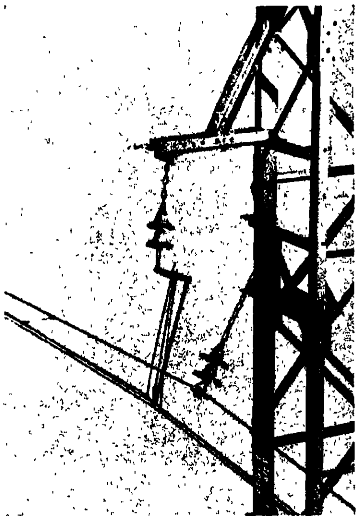
From the charts based on equivalent span lengths, curves of tension against temperature were plotted. These stringing charts were made up for all wires. The main messenger chart also had curves of sag against temperature, so that the messenger could be strung by either the sag-stick or the dynamometer method.

The system of spacing hangers which was worked out is simple, looks well, and was easy to lay out in the field. The end hanger is always 10 ft. from the suspension clamp; then, working toward the center, there are as many 20-ft. spaces on each side of the center as will go in evenly. Any space left in the center of the span is divided into from one to three equal spaces. An instrument designed to roll along the messenger was used to mark the spaces so that tapes were not needed. Hanger lengths were obtained to the nearest half-inch by a graphical method.

STRUCTURAL DETAILS

For dead-ending the main messenger the yoke set used comprises two parallel strings, each consisting of three 10-in. 18,000-lb. insulators. The auxiliary messenger and the two contact wires are dead-ended with a similar assembly giving a symmetrical appearance and equivalent electrical strength. The dead-end assembly for the yard messenger and the two contact wires consists of two 12-in. 24,000-lb. insulators in series.

At all structures on tangent track a steadyarm is used to brace the auxiliary messenger wire and both contact wires. At those structures which were followed immediately by a curve or spiral, a pull-off attachment added to the steadyarm was necessary because of the low auxiliary-messenger tension. If the contact wires are not held where slight changes in alinement occur, such as at the beginning of a spiral, they pull toward the inside of the curve enough to permit the auxiliary



The type of pull-off construction used in the main lines. Much time was saved in construction by the use of chain supports

messenger to gather slack from both sides of the steadyarm resulting in a large horizontal sag in the messenger at the point where it is clamped by the steady arm. On the sharper curves regular pull-offs without steady arms were used.

An interesting feature of this installation is the use of $\frac{3}{8}$-in. galvanized chains instead of cable and Crosby clips to hold the pull-off. Much time was saved in erection, and it is expected that by this scheme much more will be saved in maintenance. The chain link is dropped into a slot in the vertical leg of an angle, which in turn is bolted to the column or bracket.

The steadyarms were attached to the structures so as to be approximately horizontal at 0 deg. fahr., and the pull-offs, so that their slope at 0 deg. would be parallel to a line across the top of the track rails. Nearly all the brackets, angles, etc., for supporting the catenary and holding it in the correct horizontal relation to the track are fastened to the structures with bolts to facilitate shifting them to conform with changes in track alinement. The steadyarm and pull-off attachments are designed to permit a vertical adjustment of 1 ft.

After the erection was completed a final alinement of the overhead system was made, using the pantagraph of a trolley as a guide. The pantagraph was marked with white lines 1 ft. on each side of the center, and the catenary was so adjusted that the contact wires were kept within these lines at all points. It was found that very little realinement was needed. No major operating troubles have developed during the several months that this catenary system has been in service; and it has proved very satisfactory.

Telephone Toll Cable Extended

Completion of the longest telephone toll cable west of the Mississippi gives San Francisco and Los Angeles a 275-circuit all-cable communication channel, the equivalent of three of the latest-type 60-wire open leads completely equipped with carrier systems. The project cost ten million dollars, involved some heavy construction problems, and provided an important step toward an ultimate all-cable transcontinental system.

By
E. M. CALDERWOOD
Member A. I. E. E.
Pac. Tel. & Tel. Co., San Francisco

D. F. SMITH
Associate A. I. E. E.
So. Calif. Tel. Co., Los Angeles

IN THE TERRITORY of the Pacific Telephone and Telegraph Company there are four major centers of population: the triangle formed by Portland, Seattle, and Spokane on the north; the San Francisco Bay district in the center; the Los Angeles-San Diego area on the south; and the Sacramento-San Joaquin Valley area in the central part of California. Originally, telephone service was established between these centers by the use of relatively small open-wire leads. As demands for intercity service increased, it became necessary to concentrate more plant in the vicinity of these populous areas and also to enlarge the connecting routes.

About 1920 it became apparent that in several cases future telephone facilities would have to be provided by means of cable. Hence a program was entered into initially involving cable extensions from Los Angeles to Long Beach, Anaheim, and Santa Monica; a cable between San Francisco and San Jose; and between Seattle and Tacoma.

Prior to the installation of the San Francisco-Los Angeles toll cable there were two main open-wire toll routes (Fig. 1) between these points, one known as the coast route and the other as the inland route. These leads were of the phantomed type and were transposed for the use of carrier telephone systems. In addition to the voice circuits supplied by these facilities, they provided for miscellaneous services, such as telegraph, radio program supply, and picture transmission. Annual growth in the telephone circuits was such that after 1930 it was economically impossible to care for the requirements by additions to these leads.

Various plans for relief were studied, resulting in 1926 in the adoption of a program for the installation of a toll cable along the inland route. This cable, now completed, is the longest (412 mi.) west of the Mississippi; with buildings, and associated equipment, it represents an investment of approximately $10,000,000. It was placed in service September 2, 1930, and provides approximately 275 circuits, about the equivalent of three of the latest type six-arm pole leads fully equipped with carrier telephone systems. Conductors suitable

---

From "The San Francisco-Los Angeles Section of the Pacific Coast Cable Network," (No. 31-126) presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, California, Aug. 25-28, 1931.

for both long- and short-haul circuits are included in the cable (Fig. 2) and means are available for furnishing all special services previously mentioned.

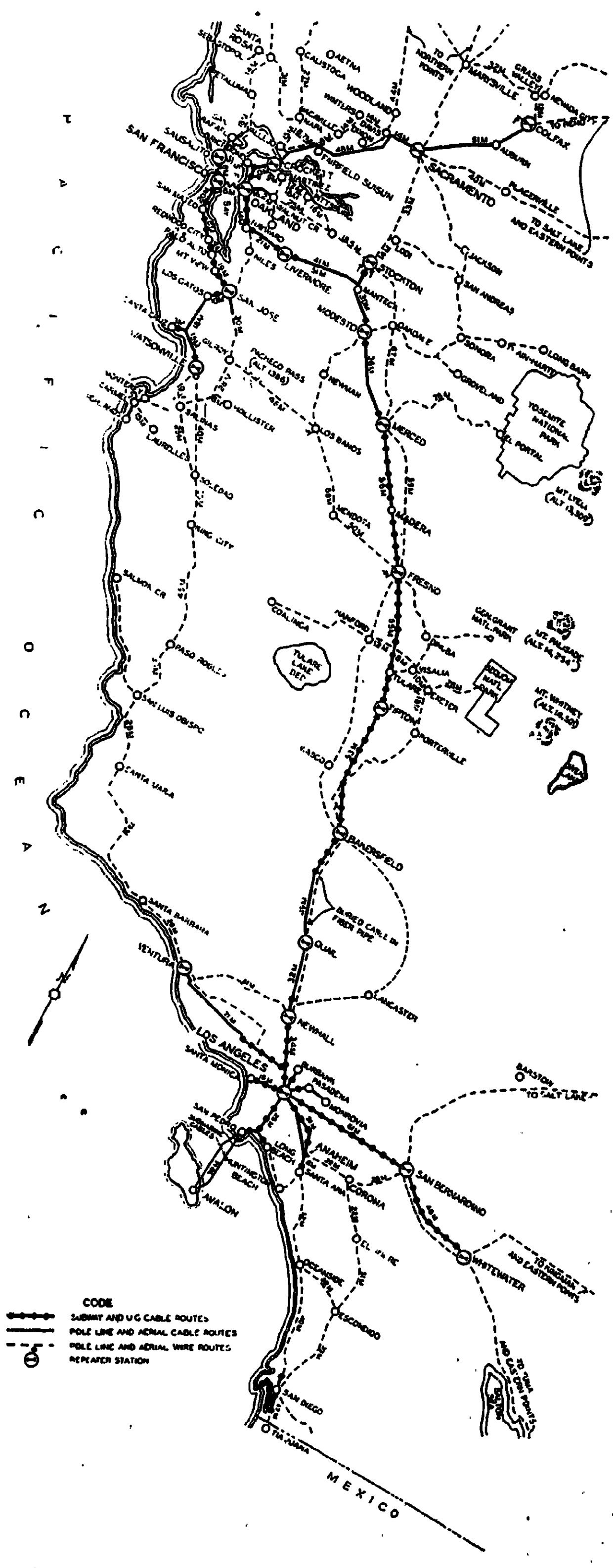


Fig. 1. Map showing open-wire and cable routes between San Francisco and Los Angeles

The cable selected was a full-size Bell System standard weighing approximately 7.6 lb. per ft. and having a lead-antimony sheath 0.125 in. thick. In this cable spirally wrapped paper-insulated wires are twisted together to form pairs which in turn are twisted together in groups of two pairs to form "quads," the unit dealt with when it is desired to use phantomed operation to enable three voice paths to be derived from two pairs of wires.

To decrease the attenuation or transmission loss, loading coils in cast iron or welded steel cases are associated with each pair at regular intervals throughout the route. Three Bell Standard loading systems were selected. One (known as H-44-25) is used for long-haul service and consists of 44-mh. coils on sides and 24-mh. coils on phantoms, these coils being placed on *H* or 6,000-ft. spacings. This loading is placed on 19-gage wire and the facilities so obtained are operated on a four-wire basis (*i. e.*, separate paths for the two directions of transmission). Having separate paths for transmitting in two directions makes greater amplification possible at repeater offices and greater freedom from difficulties arising from electrical reflection or echoes. However, with the longer four-wire circuits it still is desirable to install equipment which eliminates the echo return path. Hence echo suppressors are installed at Fresno.

The next loading system, in order of decreasing excellence, consists of the same weight of coils with the same spacing on 16-gage wire, the actual loading differing only in slight adjustments for cross-talk. These

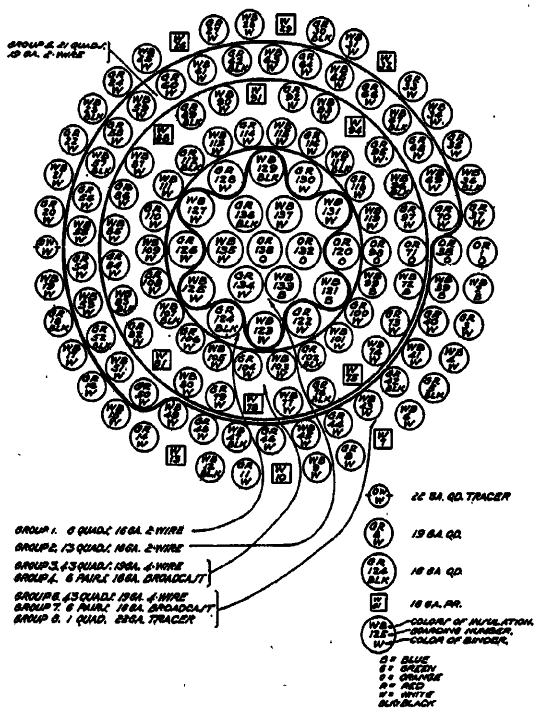

GROUP 2. 21 QUADS. 19 GA. 2-WIRE
GROUP 1. 6 QUADS 16 GA. 2-WIRE
GROUP 2. 13 QUADS 16 GA. 2-WIRE
GROUP 3. 43 QUADS 19 GA. 4-WIRE
GROUP 4. 6 PAIRS 16 GA. BROADCAST
GROUP 6. 43 QUADS 19 GA. 4-WIRE
GROUP 7. 6 PAIRS 16 GA. BROADCAST
GROUP 8. 1 QUAD. 22 GA. TRACER
22 GA. QD. TRACER
19 GA. QD.
16 GA. QD.
16 GA. PR.
COLORS OF INSULATION
BOARDING NUMBER
COLOR OF BINDER
B = BLUE
G = GREEN
O = ORANGE
R = RED
W = WHITE
BLK = BLACK

Fig. 2. Typical cross-section of Fresno-Los Angeles unit of new toll cable

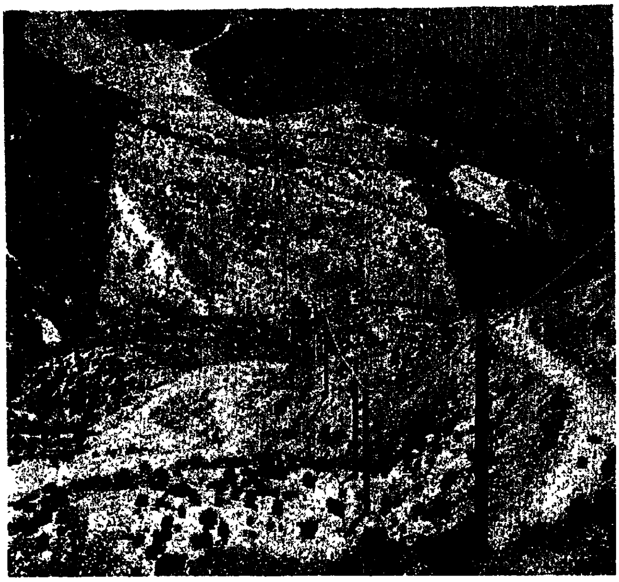


Fig. 3. Cable construction adjacent to old open-wire lead through Tehachapi Mountains

Full-treated 25-ft. Douglas fir poles on 110-ft. spans are normal, although pole heights run to 60 ft. and spans to 510 ft.

facilities are used on a two-wire basis (*i. e.*, the same path for the two directions of transmission). The third system of loading, which has been used on either 16- or 19-gage wires, provides circuits for relatively short hauls only. This system of loading (known as the H-172-63) uses 172- and 63-mh. coils on the sides and phantoms, respectively, placed on 6,000-ft. spacings. A fourth loading system (B-22) not yet in place is proposed for very high-grade service in transmitting radio broadcast programs. This loading is placed on 16-gage pairs and consists of 22-mh. coils placed at 3,000-ft. intervals.

While loading decreases the attenuation of the voice current, amplification still is required at certain intervals on the longer cable circuits. This is obtained by using vacuum-tube amplifiers or "repeaters" more or less regularly spaced along the cable. The practical limit in improvements obtainable by loading, and the lower cost of relatively small wires, made economical the placement of repeaters at about 50-mi. intervals on the Los Angeles-San Francisco cable. There are three types of these repeaters which have been standardized: the first is the four-wire amplifier consisting of two independent amplifiers for the two directions of transmissions; the second is for two-wire circuits and consists of two one-way amplifiers interconnected through devices known as hybrid coils which separate the two directions of transmission; and the third type is for use on the 16-gage B-22 loaded circuits transmitting programs for radio purposes. These are high-quality amplifiers passing a very wide range of frequencies and are used for transmitting in one direction only. The shortness of the spacing between the repeater points at San Francisco and Oakland was justified for practical and economical reasons in connection with 22-gage cable in the submarine section. (Fig. 1.)

As a general rule 20-cycle current is used for signaling on the shorter cable circuits on which telegraph circuits are not superposed. For circuits more than two repeater-sections in length, 135- or 1,000-cycle signaling currents are used, depending upon the economies of the particular case. If 1,000-cycle signaling is used, it is interrupted at the rate of 20 cycles per sec., and has the advantage of passing through and being amplified by the repeaters, necessitating no equipment for relaying around the repeaters as is the case for 20- and 135-cycle current on circuits more than two repeater-sections in length.

CABLE SELECTION AND DESCRIPTION

Individual circuits in the cables are designed to provide a predetermined grade of transmission on the basis of the "general toll switching plan," the fundamental Bell System circuit arrangement used for the layout of toll plant. In instances where more than one design will fulfil the requirements the most economical one is selected.

Although it is generally desirable to install a cable with the same make-up in all sections, it was not possible in this case, because of differences in the circuit requirements and the different rates of growth along the various portions of the route. A typical cross-section of the cable used between Fresno and Los Angeles is shown in Fig. 2 where may be noted the location of the various quads and pairs contained in it, the coloring of the insulation which enables particular quads to be identified, and the system of numbering. The quads are arranged in layer formation with the 16-gage quads in the center. The twelve 16-gage broadcast pairs and the 22-gage tracer quad are interspersed in the first and third layers (counting from the outside) of 19-gage quads placed around the 16-gage section. The heavy lines are merely to aid in visualizing the segregation of the various groups in the cable and do not represent a shield or separator of any kind. The tracer quad is used for test pairs during the construction period, and for making good any bad quad in a reel length.

The cable line comprises 138 mi. of aerial cable, 270 mi. of underground cable, and, under San Francisco Bay, 4 mi. of submarine cable. To a great extent location of the aerial plant was dependent upon the terrain and the presence of high-voltage power systems. Private right-of-way routes were available in many sections and where used provide a strip of land at least 100 ft. wide. In general the cable was placed in underground conduit in principal cities and towns, and in such other places as major moves apparently would be required in the immediate future, or where, for other reasons, such construction was economical. With the exception of 18.6 mi. of fiber duct on private right-of-way south of Bakersfield, all of the underground was of clay duct. The principal sections of the route on private rights-of-way occurred between Hayward and Stockton Junction and between Bakersfield and Newhall; mountainous country was encountered in both instances, justifying the use of private rights-of-way on the basis of savings in cable mileage.

For a distance of some 34 mi. between Merced and Madera the cable parallels an 11-kv. circuit of the San Joaquin Light and Power Corporation at a separation of about 150 ft. This exposure was considered sufficiently severe to warrant some remedial measure, and a plan was developed jointly with the power company which provided for the breaking of the exposure into several sections, and the reduction of its total length by rerouting a portion of the power line. The costs of this measure were borne jointly by the two companies.

For 57 mi. between Bakersfield and Newhall the cable is carried aerially on a private right-of-way. Thirty-five miles of this is over the Tehachapi and Sierra de La Liebre Mountains, passing through some rough country. (Fig. 3.) The route was selected to be as short and direct as possible, consistent with accessibility and economy. The most desirable location leading through fairly direct canyons and passes had to be avoided because of the presence of a 220-kv. power line from which a maximum separation was desirable to avoid inductive interference. The Ridge Route highway, a scenic motor artery which in general follows the summits of the ridges, also was impracticable because of the length of its circuitous route. In these mountains elevations of 4,500 ft. are encountered where heavy snows and occasional sleet storms occur during the winter months. Hence, in accordance with Bell System standards, this section is classified as a medium-loaded area.

Among the unusually interesting construction problems encountered in this 35-mi. desolate and practically uninhabitated section were the building of about 10 mi. of construction road and nine bridges, and the widening and grading of 9 mi. of existing narrow dirt roads or paths. The nearest railroad station from which material could be hauled was Lancaster, on the Mojave desert to the east. From that point a satisfactory road extended for about 40 mi. toward the line from which point special transportation equipment was used over the construction roads. From the railroad delivery point at Lancaster, the principal items of material were transported to the job in a series of three steps: (1) 10-ton six-wheel trucks and trailers hauled the material over as much of the distance as was accessible to them; (2) then 2½-ton four-wheel-drive trucks, and (3) in some instances tractors and trailers, were used to deliver the material to its point of use.

Loading-coil cases weighing as much as 1,675 lb. were placed approximately 6,000 ft. apart and to facilitate this work and the setting of poles, special rigging often was required. Special automotive equipment for handling the reels of cable weighing up to 6,000 lb. and for digging holes, setting poles, and pulling cable was used to good advantage. Frequently because of the ruggedness of the territory and the consequent impossibility of reaching the desired locations with power equipment many of these operations had to be performed by hand.

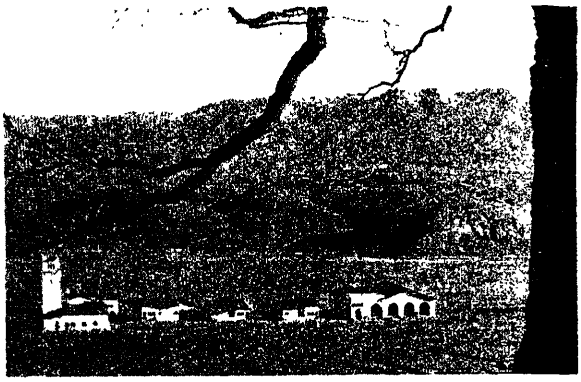


Fig. 4. Colony built for Quail repeater station

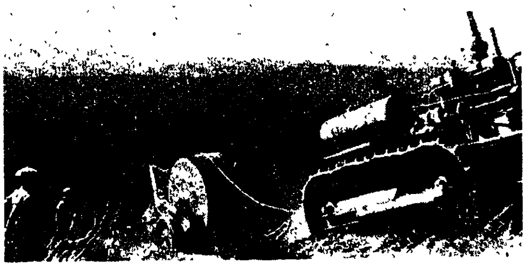


Fig. 5. A piece of typically difficult construction—lowering a reel of cable down a mountain side

PROTECTIVE FEATURES

The insulating qualities of the paper strip used for electrical separation of the conductors of a telephone cable are entirely dependent upon the exclusion of moisture. For this reason it is essential that the cable sheath be made moisture-proof and maintained in that condition. Methods which have proved valuable during the past few years make use of dry, compressed nitrogen gas, maintained under pressure within the cable sheath. A recent development is the use of continuous pressure in the cable after completion, with low-pressure alarm contactors spaced along the sheath at equal intervals. A drop in pressure in the vicinity of a contactor causes it to operate and close an alarm circuit in the cable which in turn sounds an alarm in the testing office. Gas escaping through any holes occurring in the sheath prevents the entrance of moisture for a sufficient time to permit the hole to be located and repaired. This method is in use in the fiber-duct section south of Bakersfield. The gas outfits consist of 100-cu. ft. tanks equipped with small regulating outfits which control the admission of the gas to the cable.

In general, on this job, each reel of cable was tested by injecting the gas into it under pressure after it had been pulled into place and before the sheath-ends were opened preparatory to splicing. With a pressure of 12 lb. per sq. in. throughout the cable length, any sheath opening manifested itself by a drop in pressure and was located with the aid of the hissing noise caused by the escaping gas. After each splice was completed it was tested by forcing nitrogen under pressure into it through a small hole in the sleeve, any opening being indicated by bubbles in the liquid soap with which the sleeve then was painted.

Elaborate means are taken in modern toll cables to reduce cross-talk between pairs and to reduce the picking up of noise from outside sources. The various circuit groups are kept separate, each group retaining its identity throughout each repeater section. An example of this is shown in Fig. 2 where it may be seen that the four-wire group transmitting in one direction (Group 6) is kept apart as much as possible from the four-wire group transmitting in the other direction (Group 3). The broadcast pairs are located in the four-wire group transmitting in the same direction in which they are used.

The twisted-pair and quad arrangement previously described provides the initial transposing between circuits. In manufacturing the cable, three regular types of quads are made, each differing from the other by the length required for the pair-twists, and by the length used per twist when the pairs are formed into quads. These different types of quads are used further to reduce the cross-talk between the cable circuits. To avoid the possibility of two quads in adjacent layers continuing beside each other for any particular distance, alternate layers are stranded in opposite directions during manufacture, the exact relationship between the layers shown in Fig. 2 being true only at exceptional points.

Special attention to splicing technique and splice transpositions tends to equalize or compensate for various circuit inequalities, cutting down cross-talk. Further to reduce cross-talk between two-wire circuits, at each repeater point the cross-connections are so arranged that while the phantom circuits are connected straight through, the side circuits are systematically rearranged among the quads. For the four-wire circuits a similar procedure is followed at the repeater offices which are located at the ends of circuit units. It should be noted that all these efforts to reduce the cross-talk do not result in its entire elimination, but serve to reduce it to within an acceptable limit.

Measurements and tests made on the sides and phantoms (after all the splices for a repeater section are completed and the pairs with opens, crosses, grounds, or low insulation have been cleared or tagged) include loop resistance, resistance unbalance, insulation resistance, cross-talk, transmission measurements at 1,000 cycles which are checked against calculated values, "singing-point" tests, and impedance-frequency runs on those circuits which have a poor singing point. In general, impedance runs are made on a sample of from 5 to 10 per cent of the circuits to check the correctness of loading and to locate irregularities.

BUILDINGS—EQUIPMENT—MAINTENANCE

Equipment associated with the cable is placed in eleven buildings along the route, five of which were newly constructed for the purpose and one of which, isolated in the Tehachapi Mountains, required the construction of residences for the operating personnel (Fig. 4). Equipment contained in these offices is required principally for phantoming, ringing, amplifying, and regulating purposes. Its extent may be appreciated from the fact that nearly 6,000 three-element vacuum tubes were supplied initially, although in many offices only sufficient equipment was installed to take care of a part of the circuits which ultimately will be in service in the cable.

In operating the cable, it is convenient to establish "circuit units" which consist of circuits lined up for a definite transmission value between the offices designated as "circuit-unit terminals"—San Francisco, Modesto, Fresno, Bakersfield, and Los Angeles. These circuit units are interconnected to form longer circuits, it being necessary merely to insert repeaters with the proper gain at the circuit-unit terminal offices. Each circuit unit is under the jurisdiction of a control station (San Francisco, Oakland, Fresno, Los Angeles) which is responsible for keeping it up to the required transmission standard. Test wires are set up in the cable between the various repeater points to enable each station to converse with all others as required in lining up and maintaining the circuits.

Variations in conductor resistance occasioned by daily and seasonal temperature changes may cause disturbances in the transmission losses of the various cable circuits. To compensate for this, a pilot-wire regulating system is installed in each circuit-unit section. This system consists essentially of a composited cable-telegraph circuit, or pair, known as a pilot wire, the resistance variations of which cause equipment in certain repeater stations to function and automatically compensate for variations in all circuit units. The circuits are of course lined up for average temperatures, and the regulators provide for temperature variations in either direction.

FUTURE EXTENSIONS

It is expected that future demands for toll circuits on the Pacific Coast will result in further major extensions to the long distance cable network. Among the factors which tend in this direction are: the availability of tape armored cable which may be placed directly in the ground without a subway structure; the use of automotive equipment which makes feasible the extension of heavy cable plant into rougher country; and the use of gas pressure in cables to indicate potential trouble, which makes practicable the maintenance of cables through sparsely populated areas.

These items, and others which undoubtedly will be realized in the near future, permit forecasting the extension of the coast cable network to connect the Seattle area with the Southern California area and the ultimate use of cable to connect the Pacific Coast cable network with that of the rest of the Bell System.

Engineering Progress—1731 - 1831 - 1931

The second article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" presented here predicts further industrial decentralization as a result of the wide availability of electric power.

By
MARTIN J. INSULL
Associate A. I. E. E.

Middle West Utilities
Company, Chicago

FOR SOME peculiar reason, in comparisons of present day life with that of preceding times, it seems to be assumed that progress invariably moves in one direction only. This of course is not necessarily true. We see this clearly if we review the history of the primary factor underlying the industrial changes of the twentieth century and the two centuries which preceded it.

That primary factor is power. Our life today, with its machinery, its mass production, and its teeming cities, is an outgrowth of changes in the nature of our power resources. The rural life which it supplanted likewise was determined by the nature of the power resources of the time.

Naturally the human race's work and welfare vary according to the amount of energy at its command. If energy is limited to human and animal muscle, depending upon vegetation for its fuel, it sets certain limits on the amount of possible production. Likewise, it dictates a dominantly agricultural mode of existence. However, if energy is derived from coal and water, the limits upon production tend to disappear and the importance of agriculture diminishes.

If we examine the nature of our energy resources in 1931 and compare them with the energy resources of 1831, and of 1731, we shall see quite clearly how the form of industrial structure always has been dictated by this energy factor. And by close examination, we shall see that the direction of these changes is not always the same.

The year 1731 was one in which population was widely diffused. Why? Because it was necessary to derive from agriculture the greater amount of the energy necessary to do the world's work; and agriculture is necessarily a scattered activity. Furthermore, without mechanical power there was little incentive to develop machinery or to organize people into factory groups.

In the following hundred years violent changes occurred. Freed from the definite limitations of human energy, and with the infinite resources of the coal pit at its command instead of the meager annual crops, industrial production was multiplied. To take advantage of this greater energy supply it was necessary to concentrate production because the power supply itself was concentrated. Great cities drew population from the countryside. The countryside could spare them because agriculture no longer had to produce the entire energy supply, and because agriculture itself simultaneously became more efficient.

That trend toward concentration, when superficially considered, seems to have continued to the present day. There are, to be sure, ample evidences of it. But there are still more striking evidences to the contrary; evidences that industry is tending once more away from concentration and toward diffusion.

These changes, too, are concerned with the nature of our energy supply. By 1831 power had changed the decentralized industry of 1731 into a centralized industry; in 1931 power appears to be changing industry back into a decentralized structure. The power supply of today is widely distributed. At virtually every point on the map, electricity is available in any quantity, whereas its predecessor, steam power, was to be had at relatively few points. The same is true of transportation, which after all is only another form of power.

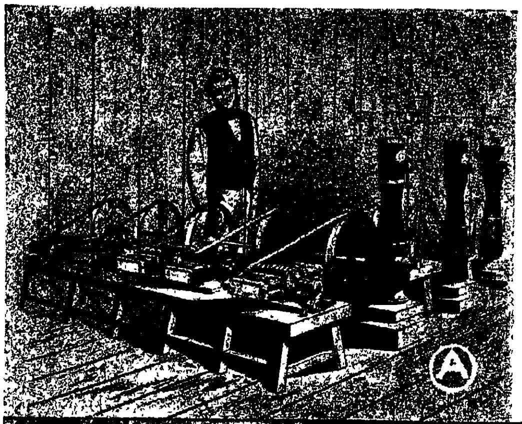
And industry is not slow to recognize the advantages of decentralization in terms of lower costs and improved working conditions. In this there is hope for those who view with despair our industrial evolution. Let them not conclude that, because we were headed toward industrial concentration for a century or more, we cannot reverse the direction of our development. We need not necessarily expect still more congested cities, still higher skyscrapers, nor a depopulated countryside. The industry of the future is more likely to reinhabit the countryside; to possess all the advantages of power machinery without the disadvantages of congestion which have hitherto accompanied it.

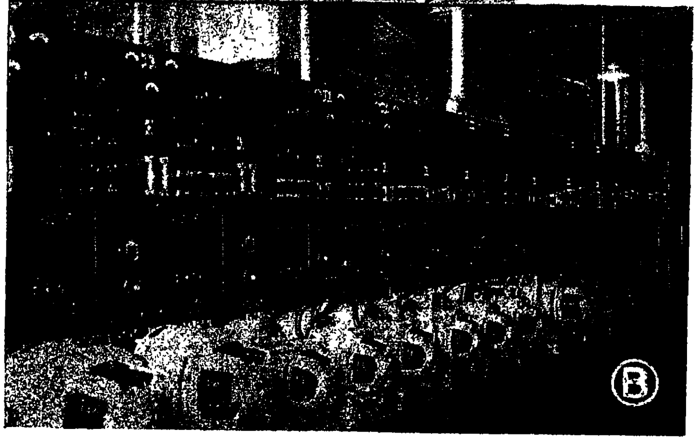
Second of series of articles written expressly for The Engineering Foundation, and released to ELECTRICAL ENGINEERING for publication. *Not published in pamphlet form.*

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

Power Supply for

FASTER telegraphic communication is expected in this day of increasing speed of transportation; and speed must be accomplished with accuracy and the highest degree of service continuity. In order to meet these service demands electrically-operated devices in great variety, including belt-type message conveyer and pneumatic tubes in the larger offices, are finding their way into telegraphic service in ever-increasing quantities. Thus it is that the power plant is more than ever the heart of the system and every means must be provided to maintain an absolutely unfailing supply of electric energy.



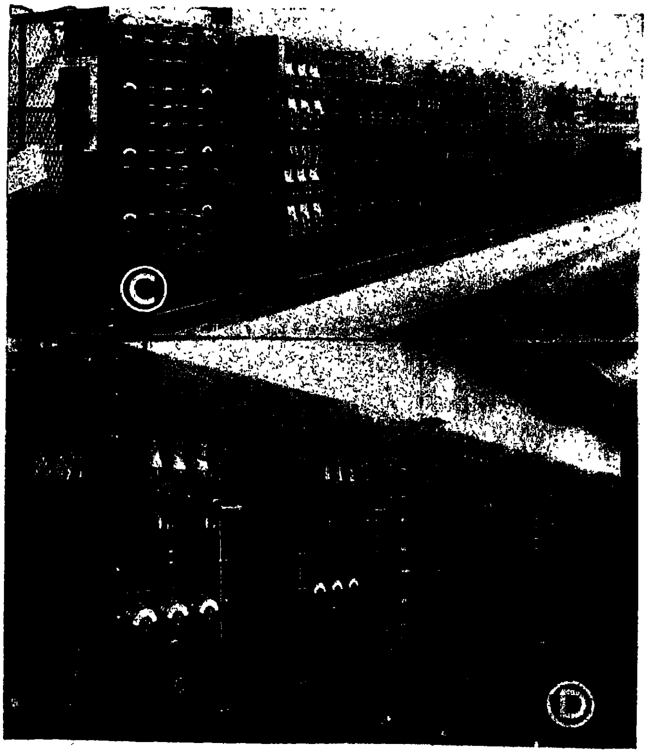


(A) In September 1880 this and two other similar steam-engine-driven dynamo groups were installed by the Western Union at 195 Broadway, New York, the first in a telegraph office. The sketch is reproduced from the *Scientific American* of January 31, 1880. Each machine delivered 40 amperes at 70 volts; four of each group in series provided potentials of 70, 140, 210, and 280 volts, with the fifth serving as an exciter. One group furnished positive potentials; one negative potentials; and the third group was a standby unit. The plant replaced 15,000 gravity cells and released 90 per cent of a 10,000-sq. ft. floor for other uses.

(B) Some of the 37 motor-generators totaling 190 hp. recently installed on the eleventh floor of Western Union's new building at 60 Hudson Street, New York, to serve 1,123 automatic and 145 Morse telegraph circuits and about 500 ticker circuits. The present maximum power demand of the New York office totals 295 kw.; 75 kw. for telegraph circuits, 50 kw. for ticker circuits, 40 kw. for belt conveyers, and 130 kw. for pneumatic tubes. For the operation of message belt conveyers, 15,722 ft. of belt and 274 small motors totaling 76 hp. are used.

(C) Distribution switchboard on the eleventh floor power room of Western Union's New York office. Duplicate sets of feeders traversing separate shafts connect this board with the telegraph board (C). On the second panel may be seen a high-speed automatic throw-over switch developed specifically to shift telegraph equipment from regular to emergency circuits upon slight potential drop in the regular circuits, and to do so without loss of synchronism in automatic equipment and circuits. The switch accomplishes the transfer from one power source to the other in less than 0.1 sec. and represents one of the most important of recent developments in telegraphic equipment.

(D) Half of the main power switchboard in the New York office basement. This section controls telegraph power including belt conveyers, compressors, a portion of the lights, emergency generating units, and the emergency storage batteries.



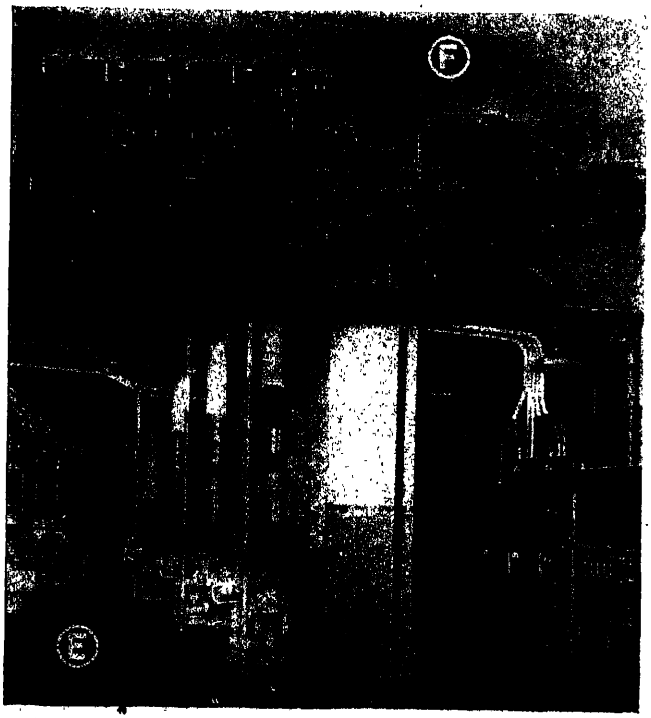
From "Telegraph Power Plants," (No. 31-62) by E. W. Griffith, Western Union Telegraph Company, New York. Presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

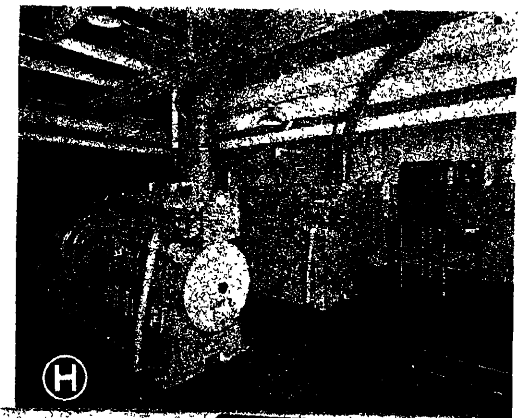
Telegraph Service

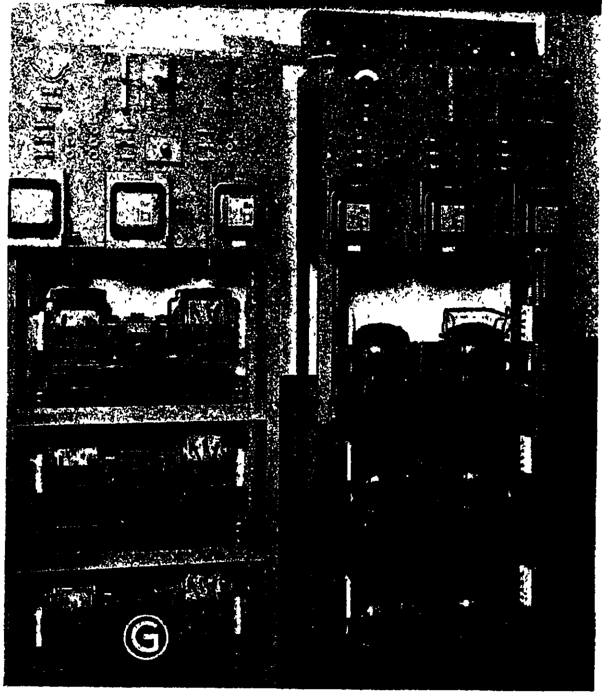
WESTERN Union policy now calls for the acquisition of power from local electric service companies instead of from private plants or batteries. This requires the use of motor-generator sets at the various offices for conversion to the desired voltages. Continuity of service is guarded by emergency engine-driven sets or storage batteries; or in the most important offices by both. At present there are about 1,085 Western Union stations equipped with a total of 4,320 motor-generator sets; 115 depend upon storage batteries for main power supply; some 450 isolated railroad stations still depend upon gravity batteries.

(E) High-speed pneumatic-tube blower installation at New York serving 50,000 ft. of tubing used for handling telegrams to 60 branch offices and 48 stations. A total of 363 hp. in blowers and compressors is required.

(F) An 8-cylinder, 200-hp., 1,200-r. p. m. gasoline-engine emergency set, typical of the new area in automotive design. The evolution of satisfactory high-speed, internal-combustion industrial-type engines and the economic advantages accruing from their use for emergency telegraph power supply have brought about some trial installations. In the new Western Union office in Boston an engine similar to that illustrated will drive a 125-kva., 208-volt, three-phase, 60-cycle alternator. It is expected to effect savings both in space required and in first cost.







(G) Motor-generators of 500-watt size and smaller generally are mounted on self-supporting steel frame "wall-type benches" specially designed to conserve space in the small offices where they are used. The sets shown are of special design, and each generator has a double commutator enabling it to serve an individual metallic circuit with 160 volts of both polarities. Switches, jacks, and cords provide for convenient transfers to meet emergencies.

(H) In some of the larger offices economies dictate two smaller emergency units instead of one larger one. The two shown are 6-cylinder, 80-hp., 900-r. p. m., gasoline engines driving 50-kva., 220-volt, three-phase, 60-cycle alternators in the Western Union's Pittsburgh office. Starting batteries and control panel may be seen in the background. All moving parts are covered and the exhaust manifolds are water-jacketed; a Maxim silencer usually is installed in the exhaust line. To decrease the transfer of noise and vibration to the building the entire sub-base is mounted on springs; and all connections, of course, made with flexible piping. In Western Union offices throughout the United States there are installed 114 emergency units; 67 gasoline, 23 gasoline (starting) and kerosene (running), 16 fuel gas, 7 semi-Diesel, and 1 full Diesel. The smallest unit is 8 hp.; the largest 120 hp.

Field Tests on Circuit Breakers

Tests show conclusively that the new high-speed oil-blast circuit breaker will clear the most severe faults within eight cycles or less, and from a system operating standpoint this type of breaker is reported as being definitely superior to other types. A careful analysis of the results shows further cause for the adoption of the multi-duty cycle. This and the two articles on the following pages outline the test procedure and discuss the conclusions reached.

CIRCUIT BREAKER field tests made during the summer of 1930 at the Philo (Ohio) plant of the American Gas & Electric Company, together with the contributions which these tests have made to the design and performance of circuit breakers are described in this article. Inasmuch as the tests involved the placing of short circuits directly on the 132-kv. bus of the largest generating plant on the entire interconnected system, before conducting such an investigation, careful consideration was given to the benefits which might be obtained.

Most prominent among the disclosures made by these tests are:

1. Circuit breaker performance.

An increased confidence in the higher ratings of circuit breakers was demonstrated. That the 8-cycle breaker has been realized was shown definitely, while in addition some progress was made toward the adoption of a multi-duty cycle. The explosion-chamber type of breaker was shown to be distinctly superior to the other types tested.

2. Circuit breaker development.

Weaknesses which now exist in the mechanical construction of the explosion-type breakers for high-speed operations but which can be corrected in future designs were pointed out.

3. System performance.

Added experience and confidence in plant operation have been provided through the large number of short circuits carried directly on the generating plant bus without apparent damage to equipment. Normally, the rate of rise of recovery voltage across the breaker contacts was found not to exceed 600 volts per microsec. System voltage dips were observed to be notably less severe when the high-speed explosion-chamber breaker was being tested than when testing the other types.

System connections for these short-circuit tests are shown schematically in Fig. 1. It may be noted that practically the entire interconnected system of the American Gas & Electric Company's group, together with some of the more important outside interconnections, were tied together in a practically normal set-up. With such an arrangement a short circuit of over 1,500,000 kva. was provided at the Philo bus, the major portion of which was supplied by the Philo plant itself.

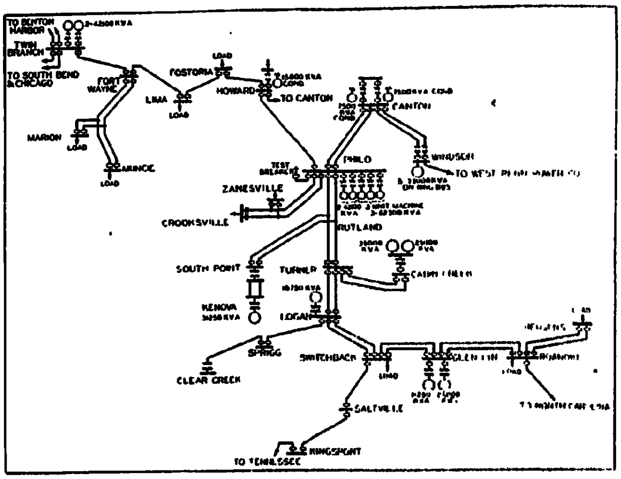


Fig. 1. System connections for the 1930 Philo 132-kv. circuit-breaker tests

In order that the tests might be carried out to take advantage fully of the entire 1,500,000 kva., a standard breaker of that rating with a 60-in. tank was used. This was mounted on a concrete mat foundation immediately adjacent to the 132-kva. Philo switchyard (see Fig. 2) and was connected to the bus by short overhead 250,000-cir. mil copper conductors.

TEST PROCEDURE

The first group of tests consisted of 28 shots on the breaker equipped with standard butt-type explosion-chamber contacts. Of these, 7 were made with the Philo generators alone supplying the short-circuit current and with no transmission lines connected to the short-circuited bus; 4 of these 7 were made with full plant capacity; 5 shots were made with the maximum available system capacity and undoubtedly resulted in a duty on the circuit breaker either at or more than its full rating.

The second series of tests consisted of 40 shots on the same breaker equipped with the new oil-blast explosion chamber and contacts (see Fig. 3). These new explosion chambers have been described in previous publications (see *The Oil-Blast Circuit Breaker*, by D. C. Prince and W. F. Skeats, ELECTRICAL ENGINEERING, Feb. 1931, Vol. 50, p. 134). These tests included a total of 16 shots with the maximum rate of recovery voltage and with no lines connected to the bus. In 7 of these 16 shots full capacity of the Philo plant was connected to the bus thus providing short circuits of from about 1,000,000 to 1,285,000 kva. Six shots were made with the maximum available system capacity, all of which as in the previous case imposed full rated duty or more upon the breaker.

The third and final group of tests consisted of 13 shots only, the tests having been cut short on account of a broken bushing on the breaker used as a closing breaker for opening shots on the test breaker. In these final tests the same breaker was used but was equipped with the older type of segmental contacts and explosion chambers. Six shots were made at intervals of from ¾ to 1½ min. with light duty and rates of recovery-voltage rise; the succeeding 6 shots were made at intervals of from 1 to 3 min. with the maximum available system capacity. The final shot, which originally was intended to be the first of a series, was made with full capacity of Philo plant and with the medium rate of rise of recovery voltage obtained with one short line connected to the short-circuited bus.

In all tests the rate of recovery-voltage rise was varied to suit by connecting or disconnecting lines to Philo generating station bus. By such manipulation three rates of recovery-voltage rise were obtained: namely, 270, 600 and 2,400 volts per microsec.

Test Results and System Performance

By
PHILIP SPORN American Gas & Elec. Co., New York
Fellow A. I. E. E.

H. P. St. CLAIR American Gas & Elec. Co., New York
Member A. I. E. E.

SYSTEM DISTURBANCES due to the tests were not serious and caused but little trouble and but few complaints except from consumers at points nearby. Recording voltmeters were installed during the tests at all of the important 132-kv. substations on the system. Typical charts from these recorders are shown in Fig. 4. While inertia and overtravel in a voltmeter of this type are responsible for some of the variations in the charts, nevertheless a clear comparison may be noted between the severity of disturbances caused by high speed and by ordinary circuit breakers. The most striking comparison is revealed by the charts obtained at points close to the Philo plant, such as those taken at Crooksville. Here again the inertia of the moving pen instrument plays a large part in the record obtained, but at the same time a fairly accurate comparison may be drawn. In addition it is felt that a dip, the duration of which is too short for the recording voltmeter pen to follow, may also be too short to cause a synchronous machine to fall out of step.

SUMMARY OF IMPORTANT RESULTS

In general the principal objects for which the tests were undertaken were quite fully realized. The manner in which the tests will prove of real benefit from the standpoint of system performance is indicated in the following listing:

1. 2,500,000-kva. breakers now feasible.

In view of the fact that a test breaker equipped with a 60-in. tank successfully interrupted a 1,735,000-kva. short circuit, there is little doubt

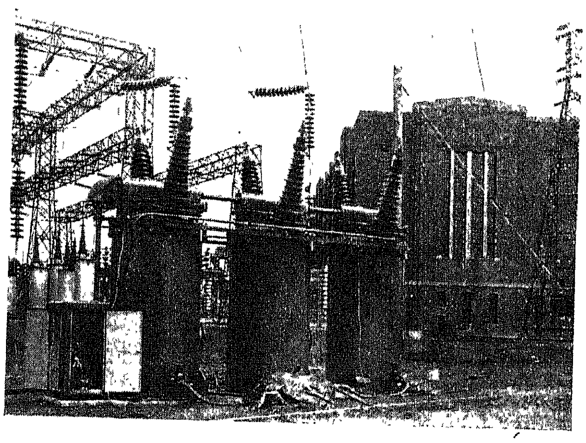


Fig. 2. The 132-kv. 1,500,000-kva. oil circuit breaker with 60-in. tank used in the tests. Note proximity to substation and power house structures

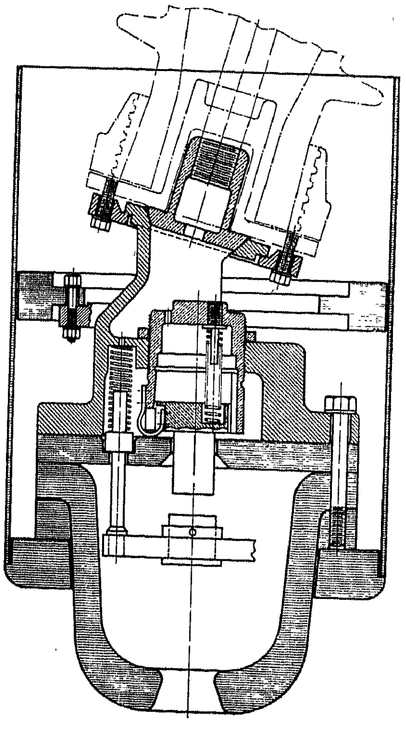


Fig. 3. Circuit breaker explosion chamber with new oil-blast contacts

---

From "Oil Circuit Breaker Tests—Philo 1930, Aims, Set-Up and Results from a System and Operating Viewpoint," (No. 31-25) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

but that standard breakers with 72-in. tanks will operate satisfactorily under their rated duty of 2,500,000 kva. This positive assurance is of value, in that it enables the engineer to plan system expansion along the most desirable lines without being hampered by fears of circuit-breaker limitations.

2. The 8-cycle breaker a definite realization.

All short circuits in tests on the new oil-blast explosion chambers and contacts were cleared in 8 cycles or less. High-speed breaker operation will greatly accelerate the clearing of a faulty line, which is particularly important where two or more parallel lines are being protected. It is also valuable for preventing a complete loss of voltage on one of two interconnected systems by quickly clearing the interconnecting tie when the load approaches its static-stability limit.

3. Increased confidence in plant performance.

Ability of the generating station equipment to withstand these heavy short circuits without apparent damage has proved beneficial in the training and experience of the operating personnel at Philo; a greater degree of confidence in plant performance has resulted.

4. Adoption of the multi-duty cycle predicted.

Definite progress for the adoption of the multi-duty cycle for circuit-breaker performance has been realized through a demonstration of the ability of the breaker to handle successively a large number of heavy short circuits without intermediate inspections or changes of oil.

5. Design defects were revealed.

Two explosion-chamber failures occurred during the course of the tests. These were caused apparently by the general weakness of the chambers and not by other faults of design. It is believed that subsequent changes in design will prevent a recurrence of such failures.

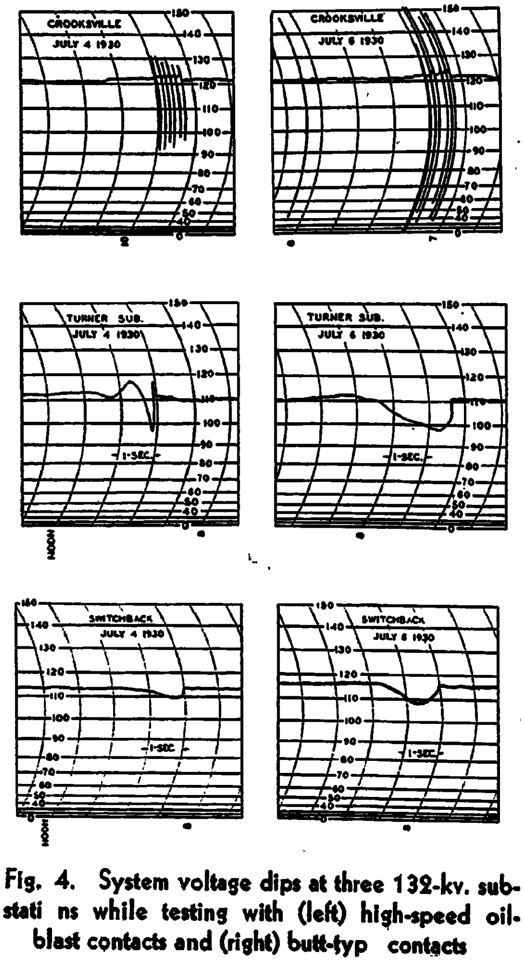


Fig. 4. System voltage dips at three 132-kv. substations while testing with (left) high-speed oil-blast contacts and (right) butt-type contacts

Test Results and Circuit Breaker Behavior

By

R. M. SPURCK General Elec. Co.
Associate A. I. E. E. Philadelphia

H. E. STRANG General Elec. Co.
Associate A. I. E. E. Philadelphia

PERFORMANCE of different types of breaker contacts, and rates of recovery-voltage rise, are the principal items receiving particular attention in this analysis of the Philo circuit breaker tests. As stated previously the rate of recovery-voltage rise was manipulated by varying the number of lines connected to the Philo station bus.

In the 28 tests made with the butt-type contacts, the kva. interrupted ranged from 268,000 to 1,640,000. The range of short-circuit duration was from 7.5 to 39 cycles, while breaker operating time varied from 7 to

---

From "Circuit Breaker Field Tests on Standard and Oil-Blast Explosion-Chamber Oil Circuit Breakers," (No. 31-26) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

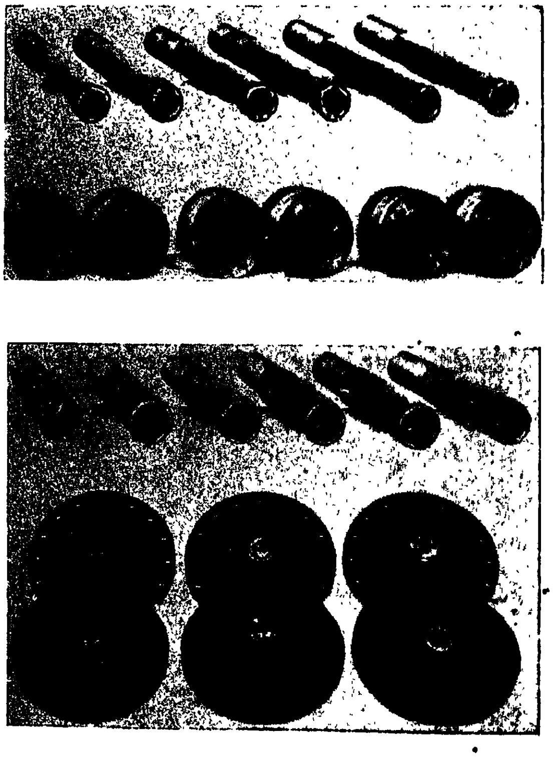


Fig. 5. Condition of contacts after tests. (Above) butt contacts after 28 tests; (below) oil-blast contacts after 40 tests

38 cycles. Arc duration ranged from 4.5 to 36 cycles; arc length from 11.5 to 32 in. Maximum tank pressure recorded in this series of tests was 36 lb. per sq. in., while the average was 10 lb. Although slight mechanical difficulties were encountered they were not of a fundamental nature and will be corrected quite readily by minor changes in design. Although these butt-type contacts were somewhat burned after the tests, as may be seen in Fig. 5, their condition was such that they could have been kept in operation for many more tests.

SUPERIORITY OF NEW EXPLOSION-CHAMBER CONTACTS

Results of the 40 tests made with the hollow-type contacts operating in the new type oil-blast explosion chamber the kva. interrupted ranged from 177,000 to 1,735,000. The short-circuit duration varied from 5.5 to 9 cycles, and breaker operating time from 4.5 to 8 cycles. Arc duration varied from 1.6 to 5.7 cycles, while arcs from 2.5 to 14.5 in. were recorded. On the last six tests of this group, all in excess of 1,500,000 kva. and made at intervals of about two minutes, the average tank pressure was 8 lb. per sq. in., the maximum being 11 lb. The condition of these contacts after test may be seen also in Fig. 5. Actual measurement indicated that a total of less than ¼ in. of contact metal had been burned away from the arcing surfaces. In order to determine their suitability for further operations, these contacts were returned to the factory and subjected to a heat run using twice the breaker-current rating; the resulting temperature rise was less than 30 deg. cent.

In the third series of tests with the segmental-type contacts, 7 tests ranging in value from 940,000 to 1,400,000 kva., were made in 10 min. Short-circuit duration varied from 12 to 18 cycles, corresponding breaker operation ranging from 11 to about 15 cycles. Arc duration varied from 4.5 to 7.2 cycles; arc length from 11.3 to 14.8 in.

A comparison between the performance of the butt-contact breaker and that of the oil-blast contact breaker is shown in Table I. Effects of the rate of recovery voltage rise upon arcing time and arc lengths may be noted quite readily. Average arc duration for the butt-type contacts was 8.6 cycles as compared with 3.5 cycles for the oil-blast contacts. A comparison between arc lengths shows an average of 18 in. for the butt contact and 6.8 in. for the oil-blast contact. Average contact-opening speed for the oil-blast breaker was 9.5 ft. per sec. as compared to 13 ft. per sec. for the butt contact.

TABLE I—PERFORMANCE COMPARISON FOR BUTT AND OIL-BLAST BREAKER CONTACTS

Butt Contacts

Lines connected to bus	Calculated volts per microsecond	No. of tests	Av. arc duration cycles	Av. arc length in.
3	270	17	6.2	15.5
1	600	4	7.1	17.0
0	2400	7	15.0	24.5
Total 28 tests	Average		8.6	18.0

Oil-Blast Contacts

Lines connected to bus	Calculated volts per microsec.	No. of tests	Av. arc duration cycles	Av. arc length in.
3	270	15	2.6	4.5
1	600	9	3.7	7.1
0	2400	16	4.1	8.8
Total 40 tests	Average		3.5	6.8

CONCLUSIONS

After a careful analysis of the test results, the following conclusions seem justified:

1. Rate of recovery voltage rise affects to some extent the interrupting performance of the breaker.
2. Standard breakers now available commercially will operate satisfactorily on the highest rates of recovery-voltage rise now encountered (about 600 volts per microsec.).
3. The oil-blast breaker has demonstrated a distinct superiority over the other types of breakers tested.
4. Standard oil-blast breakers now available commercially possess an over-all operating time of 8 cycles or less.

The Orient Turns to Automatic Telephones

By
Y. K. CHOW
Member A. I. E. E
Hangchow, China

MANY great poets of China repeatedly have described the beauty of Hangchow. It is the capital of the Province of Chekiang, one of the smallest but richest in the country. At one time its leading glory was the fame of its beautiful landscape, but the town now is winning a standing also through the increasing application of modern engineering. Among several developments the most recent and perhaps most important is the new automatic telephone exchange system which now serves the whole area.

Only a little more than twenty years ago telephone development was started by commercial enterprise in this ancient capital; subsequently the system was transferred to a government organization. A little later again to become a commercial enterprise; present

---

Contributed by Y. K. Chow, chief engineer, Provincial Telephone Administration, Chekiang Provincial Government, Hangchow, China. Not published in pamphlet form.

developments are being made by the Provincial Government. In the early days telephone service was not in the general demand that it is today; hence growth and development came slowly. Also, financial difficulties and the lack of suitable technical study caused the design and growth of the system to be governed largely by expediency. Subsequently the age of the switchboard and other equipment, and the poor condition of the line plant, prohibited any major attempt for modernization without complete system reconstruction.

In 1927 the Provincial Government decided to construct a network of long distance telephone lines to link together all the cities in the province, and to connect also to Nanking and Shanghai. Since that time toll service has grown rapidly, with a consequent expansion in the problem of improving local service in the Hangchow area. Meanwhile, the city's telephones had increased gradually until there were five magneto-type exchanges scattered over the whole area, the largest of which had a capacity of 1,200 lines. Early in 1929 the government completed its plans for taking over the existing exchanges from the operating company and invited bids for system rehabilitation from leading telephone manufacturers throughout the world.

In addition to the economic questions that had to be settled in connection with such a major undertaking, there were the problems of language difficulty, training and maintenance of staff and operators, and the ever-present matter of public opinion. Ultimately the rotary-type of machine-switching system was adopted as best suiting the service requirements, as well as satisfying economic limitations.

The present equipment consists of one 2,700-line exchange with a building and power plant which provides for an ultimate of 5,000 lines, and one 300-line exchange designed and equipped for an ultimate of 500 lines. The existing manual exchange in the south of Hangchow will be converted shortly to automatic operation. Also it is hoped that conversion of the rural exchanges to automatic operation may be carried out in the near future.

Radiotelephone Service is Expanding

With 91 per cent of the world's telephones already provided with facilities for direct international conversations, plans and developments are progressing to provide extensions. Present services are outlined here and some data given covering the Hawaiian link now under construction.

By
J. J. PILLIOD
Member A. I. E. E.

American Tel. & Tel. Co., New York

SINCE January 7, 1927, when commercial radiotelephone service first was established between New York and London, continuous and important developments have been made in the application of radiotelephony to intercontinental communications. Also, there has been a generally sustained increase in the public demand for this class of service to the end that today the Bell System in cooperation with the British Post Office has four radiotelephone circuits to London, the original long-wave channel supplemented by three short-wave channels. By means of these, telephone subscribers in the United States, Canada, Cuba, and Mexico may be connected to practically any telephone in Europe, in the city of Ceuta, Northern Africa, in part of Australia, and in Java, Dutch East Indies.

Service to all European points and to Ceuta is furnished through London where connection is made to the submarine cables and land line facilities making up the European telephone network. As yet Russia, Greece, Turkey, and a few of the Balkan States cannot be reached from the United States over this network. Service to Australia is given by switching the New York-London radio circuits at the latter point to a short-wave radiotelephone channel between London and Sydney. Service to Java is furnished through London to Amsterdam or Berlin, where connection is made to a short-wave radio channel operated between those points and Java by the Dutch Telephone Administration.

Transatlantic telephone messages between the United States and Europe during the first six months of 1931 were about 20 per cent greater than for the corresponding period for 1930. While the basic rate, which is the rate from New York to London for a 3-min. period, was reduced from $45 to $30 on May 11, 1930, the increase in traffic is considered very satisfactory in view of the general business conditions which have

---

From "Intercontinental Radiotelephone Service From the United States" (No. 31-129) presented at the A. I. E. E. Pacific Coast convention, Lake Tahoe, California, August 25-28, 1931.

existed on both sides of the Atlantic, and is an indication that this service continues to be of increasing usefulness to the public.

In December 1929, a ship-to-shore short-wave radiotelephone service was established on a commercial basis through New York with the steamship "Leviathan." Since that date service has been opened with five more of the larger liners plying between North America and various European ports, the "Olympic," "Homeric," "Majestic" the "Belgenland," and the "Empress of Britain." While at present this service is furnished normally only to ships in the Atlantic area, contacts were made last winter with the "Belgenland," during a large part of its cruise around-the-world, and with the "Homeric" then cruising in the Mediterranean.

The Bell System, in cooperation with the International Telephone and Telegraph System, established on April 4, 1930, a short-wave radiotelephone channel between New York and Buenos Aires. Through Buenos Aires, service may be given by land line connections not only to other parts of the Argentine Republic, but also to the great majority of telephones in Uruguay and Chile.

Construction has been completed recently to the end that the South American service could be enlarged to include Rio de Janeiro, Brazil. Plans for the radiotelephone system to work with Rio de Janeiro were on a basis somewhat different from those for the services heretofore established from the United States, and it may be of interest to outline briefly the arrangements made. The previously established services contemplated the full-time use of one or more complete radiotelephone circuits whereas service to Rio de Janeiro was planned on the basis of sharing facilities already provided for service to Buenos Aires.

In the United States the transmitter operating with Buenos Aires was provided with an additional antenna directed toward Rio de Janeiro; and at the receiving station there was installed a complete new receiving unit adjusted to receive from Rio de Janeiro. At the transmitting station, switches were provided for the rapid transfer of the transmitter from one antenna to the other, while at the receiving station the two receiving units serve to enable the New York control office to keep in constant touch with both distant transmitters. This arrangement permits the maximum use of equipment and facilities and seems to offer a promising means of providing for the extension of radiotelephone service to a number of points to which it may be desirable to furnish service, but where the cost of apparatus for full-time channels cannot at the time be justified. This arrangement offers also an opportunity to reduce the number of frequency assignments required, because a number of points may be served from one transmitter using the same transmitting frequencies where the conditions permit. It is expected that this general method will find considerable application in economically extending existing services. One set of transmitting equipment, which is the expensive item, can be used for service to a number of points to the extent permitted by traffic loads, by merely providing the necessary antennas and receivers.

The radiotelephone services established to date and previously referred to, now make possible the connection of telephone users in this country to more than 91 per cent of the world's telephones. From the map shown in Fig. 1 it may be seen that these existing facilities provide the ground work for furnishing telephone service from North America to the East and South. Preliminary studies have been made of the possibilities, probable demand, and usage of telephone service from the United States to all parts of the world. A worldwide service of this kind is something that is extremely interesting to contemplate, but it is obvious that while considerable progress has been made in establishing such a service, an objective of this magnitude must be approached with due consideration to such factors as equipment and antenna development, costs, probable usage, differences in time and languages, and availability of satisfactory wavelengths.

In line with the desired objective of extending service where practicable, plans have been completed recently and construction work is now in progress to establish in conjunction with the Imperial and International Communications, Ltd., a short-wave radiotelephone channel between New York and Hamilton, Bermuda,

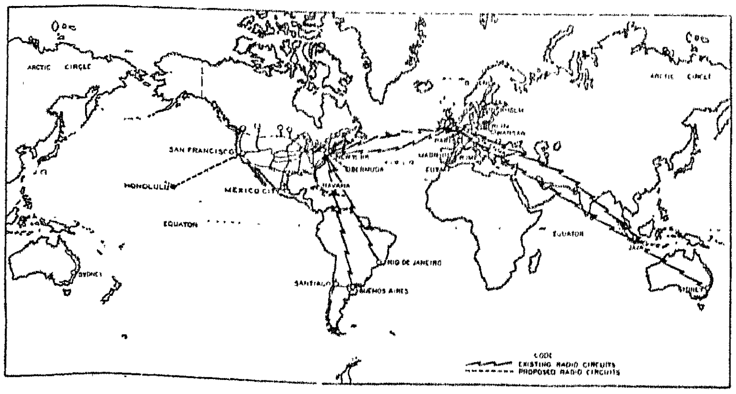


Fig. 1. International radiotelephone connections of the Bell System as of August 1931

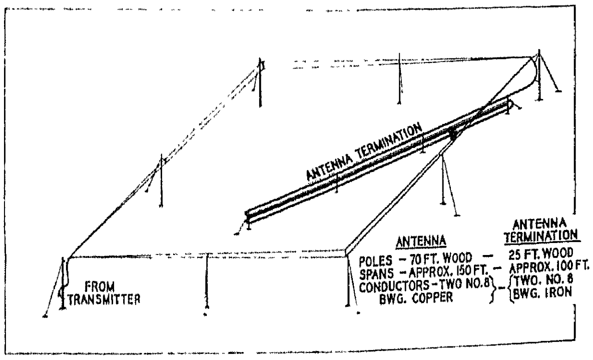

ANTENNA TERMINATION
FROM TRANSMITTER
ANTENNA
ANTENNA TERMINATION
POLES – 70 FT. WOOD – 25 FT. WOOD
SPANS – APPROX. 150 FT. – APPROX. 100 FT.
CONDUCTORS – TWO NO. 8 BWG. COPPER – TWO. NO. 8 BWG. IRON

Fig. 2. Schematic diagram of the "horizontal double-V" transmitting antenna for Hawaiian service

there to connect with the land line facilities serving the Bermuda Islands. This radio circuit in general will closely resemble the other short-wave radio circuits previously established. The transmitter will be considerably smaller and of lower power, however, (500 watts unmodulated carrier outputs compared to 15 kw.) since the distance to be covered is only about 700 mi. compared to about 3,400 mi. between New York and London, 4,800 mi. between New York and Rio de Janeiro, and 5,300 mi. between New York and Buenos Aires. It is expected that the Bermuda system will be ready for operation late this year.

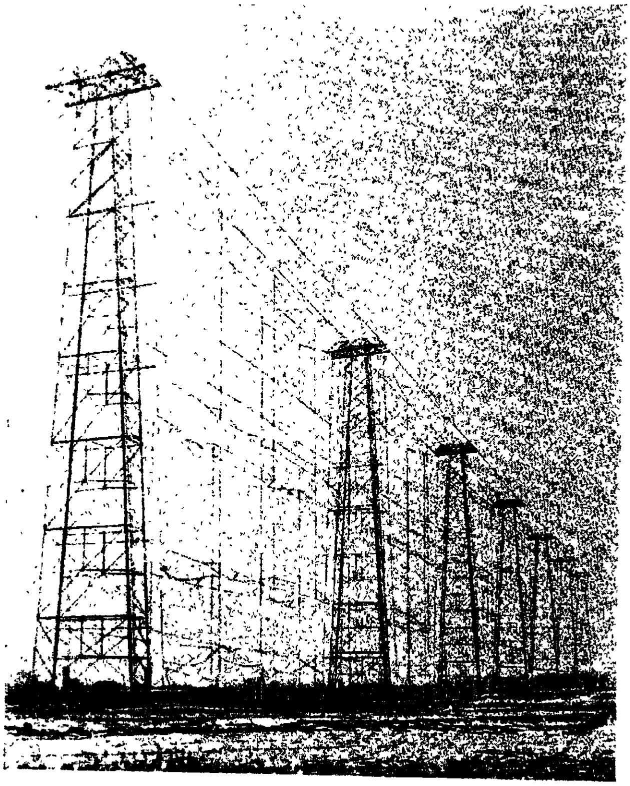


Fig. 3. Antenna towers and curtains of the type used for South American and transatlantic service

During the past 1½ years right-of-way has been acquired and two test antennas have been constructed at Bradley, Maine, near Bangor. These test antennas were constructed for experimental purposes looking forward to supplementing the existing New York-London long-wave circuit now working at 60 kc. with an additional long-wave circuit operating at 68 kc. These antennas have proved effective at Bradley, and plans now are in progress for the construction of a new long-wave transmitting station at that point. The receiving station for the additional long-wave circuit is planned for Houlton, Maine, the receiving point for the existing long-wave circuit. Owing to the magnitude of this undertaking it is expected that about three years will be required to construct the new long-wave system.

In the Pacific area the points which in the future might logically be furnished with direct radiotelephone connection with the United States include the Hawaiian and Philippine Islands, Japan, China, Australia, New Zealand, and Alaska. A transpacific short-wave radiotelephone system is now under construction, joint arrangements having been made with the Mutual Telephone Company of Hawaii to set up the initial circuit from California to Hawaii.

The transmitting station for the transpacific service is being established at Dixon, Calif., in the Sacramento Valley about 20 mi. southwest of Sacramento and the receiving station, at Point Reyes, Calif., on the Pacific Coast about 35 mi. north of San Francisco. The Dixon site contains about 640 acres and the Point Reyes site about 520 acres. These sites were selected after a rather extensive survey of the west coast of the United States during which consideration was given to avoiding, for receiving station purposes, areas too near radio transmitting stations and other sources of interference and, for transmitting station purposes, areas too near radio receiving stations. Consideration was given also to obtaining for both stations tracts of land of reasonably flat contours, free of mountain ranges which subtend angles of more than 2 or 3 deg. with the horizontal in the directions of transmission or reception. It was necessary that both sites be economically accessible for telephone, power, and transportation facilities.

The transmitter building at Dixon, a 40 x 60-ft two-story brick-and-concrete structure, is designed to accommodate two equipments although only one will be installed initially. In general, the transmitter is similar to those at Lawrenceville, N. J., consisting of several individually and carefully shielded units mounted side by side. These units include a two-stage audio-frequency amplifier, a modulator, a piezoelectric quartz crystal oscillator with two harmonic generators, and a two-stage radio-frequency power amplifier. The output of the two-stage audio-frequency amplifier is used to modulate the plate voltage of the modulator unit which contains two 250-watt tubes in a push-pull circuit. The modulator receives its carrier frequency direct from the second harmonic generator which in turn is fed by the first harmonic generator and the crystal oscillator.

The crystal oscillator is contained in an electrically heated oven the temperature of which is carefully regulated to 50 deg. cent. ± 0.05 deg. This arrangement holds the transmitted carrier frequency constant within very narrow limits. The output of the modulator unit then is applied to the grids of the two-stage radio-frequency amplifier. The first stage contains two 10-kw. water-cooled tubes and the second stage contains six. These tubes are arranged in push-pull circuits and the entire system is carefully balanced to ground. The unmodulated carrier output power of the last-stage amplifier is about 15 kw. which, under conditions for 100 per cent modulation, is equivalent to 60 kw. at the peak of the modulation cycle.

From the transmitter the radio-frequency energy is fed over an open-wire transmission line to the transmitting antenna about 800 ft. south of the building. This initial transmitting antenna for the Hawaiian service is of the horizontal double-V type (Fig. 3) recently developed by the Bell Telephone Laboratories. This type of antenna is a diamond-shaped structure consisting of one or more horizontal elements supported on wooden poles, the longer axis pointing toward the desired receiving station. The antenna is driven from the rear apex of the diamond and when suitably terminated at the opposite end, has a good unidirectional characteristic. This antenna has another very desirable characteristic in that, within certain limits, it is effective over a range of frequencies. For transmitting to Hawaii the initial antenna is designed to handle two frequencies in the vicinity of 7 and 14 megacycles. While varying somewhat with the frequency being transmitted, the gain of this antenna as compared to a single-element half-wave vertical antenna ranges from 8 to 16 db.

Comparison of the details revealed in Figs. 2 and 3 will indicate the relative simplicity, and consequently the relative economy, of the horizontal double-V antenna. This is even more strongly indicated when it is considered that in the vertical type shown each antenna occupies two spans between the 185-ft. steel towers, and that each antenna is effective for only the one frequency for which it was designed. The development of this relatively inexpensive antenna is of particular significance at this time because, if radiotelephone service is to be opened to points which do not justify the provision of individual channels, the number of antennas for use with existing equipment may be expected to increase materially in the next few years.

At the Point Reyes receiving station the building is a one-story 26 x 40-ft. semi-fireproof structure of reinforced concrete designed to house several radio receivers and their associated power and voice-frequency apparatus. However, the initial installation comprises a single receiver made up of individually shielded units. It employs two stages of screened-grid radio-frequency amplification, a first detector, an intermediate-frequency amplifier with input and output filters, a second detector and an audio-frequency amplifier. From the output of the intermediate-frequency amplifier a part of the received energy is diverted, put through a special two-stage intermediate-frequency amplifier, rectified, and supplied to the automatic gain control which in turn tends to keep the receiver output volume constant by controlling the bias potential on the radio-frequency amplifier and the first-detector grid circuits. In this receiver the first two panels which contain the equipment up to and including the first stage of intermediate frequency amplification are duplicates. By means of a switch the equipment in either of the first two panels may be connected to the rest of the receiver. This arrangement makes it possible to switch from one frequency to another with only slight tuning adjustments and therefore with the minimum loss of time.

The receiving antenna is similar in construction to the transmitting antenna already described. It is about 500 ft. northeast of the receiving building and is designed to receive two frequencies, 16,195 kc. and 7,535 kc. Connection to the receiver is by means of a concentric-conductor transmission line run underground at a depth of about 18 in. This type of line is used because of its low transmission loss at high frequencies and because of the shielding effect of the grounded outer conductor. The outer copper tubing is of 1⅝-in. outside diameter while the inner copper tubing is of ⅜-in. outside diameter. Spacers are of Isolantite.

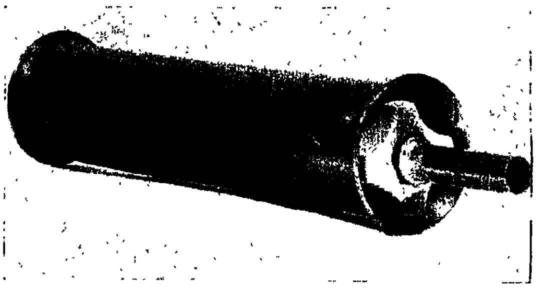


Fig. 4. Section of concentric copper transmission conductor for connecting the receiving antenna t the radio receiver

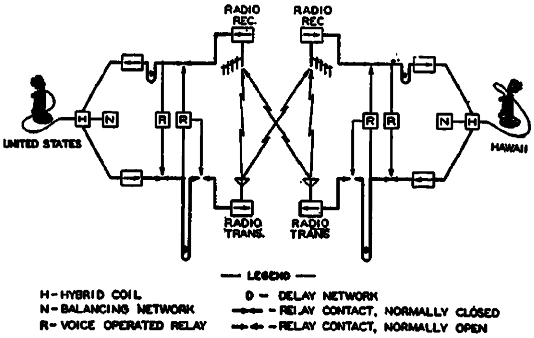


Fig. 5. Fundamental arrangements of voice-operated devices for the transpacific radiotelephon circuit

At San Francisco the terminal control equipment will be located on the first floor of the Pacific Telephone and Telegraph Company's Grant Avenue toll building. To this location are brought the transmitting and receiving radio circuits, as well as the interstation communication and order wires. Equipment at the terminal station is the same as that installed at New York for the transatlantic services and which has been described in a paper previously presented.

From the terminal control room the radio circuit is carried to a special position at the San Francisco toll switchboard where connection may be made to land line circuits extending to all parts of the country.

It is expected that service to Hawaii will be available commercially early in 1932. To the people of Hawaii the establishment of this service will offer for the first time a regular telephone connection with the North American Continent. In addition, it will afford opportunities to make tests and obtain actual field data leading to still further extension of radiotelephone communication to such other transpacific points as may be decided upon in the future.

Voice Training on a Scientific Basis

TRANSMITTING, recording, reproducing, and amplifying of sound by mechanical, electrical, and photographic devices have brought an industrial need for an exact science of sound. In 10 years of research with modern instruments and laboratory methods, and with the latest knowledge of physiology, enough has been learned to establish principles for training a voice understandingly although much additional research is needed.

Hundreds of tests were made upon voices, trained and untrained; for example, an investigation of the expulsion of breath during phonation. The singer put on a French gas mask; in its eye-piece was a telephone transmitter; rubber tubing went from the mask to a spirometer and to the air. Flutter valves allowed breathing in from the outer air and out into the spirometer, but stopped escape into the outer air or out of the spirometer. The specially designed transmitter was connected to a special amplifier and thence to an oscillograph. The singer sang several tones on different vowels at various pitches and intensities, each tone held 8 to 12 sec. Readings of the volume of air expelled per second were taken.

Observation of great singers has shown that they never produce a "dead," steady tone except at pianissimo. The tone fluctuates in intensity with perfect regularity. This fluctuation, very wide at high intensity, is accompanied with a slight fluctuation of pitch. This vibrato is the result of an impulse periodically applied to all the muscles which coordinate in the act of phonation. Its frequency is about six per second, but can be increased. Thus all the time the singer is phonating he actually is alternately singing and silent, rapidly and regularly. As the intensity rises the "on" impulse is more vigorous and the swing of the vibrato increases. Since at mezzo forte, when the technic is good, the intensity of the tone should increase as the pitch rises nearly up to the top of the singer's range, the vibrato should increase in amplitude as the scale is ascended. The vibrato decreases as the intensity drops until a point is reached at which a stream of air actuates the vocal cords, when it disappears altogether. This concept of an "on" and "off" impulse is very different from the old notion of steady control of a stream of breath.

A great voice is not due to anatomical peculiarities but to mental and emotional capacity and tractability. The human voice is a sound-producing instrument governed by the laws of sound and of physiology; it consists of a motive force (the *pressure* of the breath), a vibrator (the vocal cords), and a resonator (a set of adjustable cavities in the head and throat). Voice starts in a mental concept which brings the necessary muscles into action. A singer must have a mental concept of the pitch which he is about to sound. If this concept, or the receiving mechanism of the ear, be faulty, a pupil cannot be made to sing, although his speaking voice may be trained. Two groups of muscles, one of seven and the other (far stronger) of two, bring the vocal cords into tension and hold them there. When a mental concept initiates the nerve impulses supplied to the larynx, these muscles come into action and the vocal cords are set to the proper length, tension, and position. If the singer starts from pianissimo, where the breath pressure is at a minimum, and increases the intensity and therefore the breath pressure or the amplitude of the vibrato to fortissimo, the muscles must take on additional tension. The lighter muscle group should take tension to a point at which it would overload; then tension of the stronger group must be increased.

So long as the vocal cords are held in tension against pressure of the breath by means of additional tension on the lighter muscles, the singer or speaker is using the "upper register" (falsetto); as soon as the stronger muscles start to take on added tension, he is using the "lower register." *Registration* provides the proper method of controlling the *intensity*, not the pitch. The registers should be isolated and trained separately; only when fully developed should they be coordinated. Improper coordination of the laryngeal muscles accounts for the partial or total loss of voice of most of the great singers at an age at which they should be in their prime.

From "breath expulsion-intensity" curves, a person trained in this new science will be able to make an accurate technical criticism of a voice without having heard it. The "breath control" doctrines, long ac-

---

From *ResearchNarratives*, June 15, 1931, published by The Engineering Foundation, 29 West 39th Street, New York, N. Y. Based upon information contributed by Douglas Stanley, M. S., Assoc. City Guilds of London Inst., Fel. Acoustical Society of America, N. Y.

cepted, are fallacies. Tremolo is caused by a fluttering of the walls of the resonating cavities. The vibrato is the means for moving the voice correctly from tone to tone; it allows the singer to keep perfect time and rhythm; it can be improved and controlled by training.

The range of every properly produced voice should be at least three octaves; some persons may attain nearly four. Faulty registration and resonance adjustment can curtail the range 50 per cent or more; also reduce the power to an incredible degree. The mouth should not be used as a resonator. When a person is phonating the muscles used in the act of phonation should not be relaxed but in proper tension balance.

There is no fundamental difference between the singing and speaking voices except in so far as vowels are more sustained in singing. There is no vibrato in speech. In singing the intensity is far greater (thus the general pitch is far higher), the range far wider, and articulation much stronger than in speech. In speech, low tones are most effective; hence all normal speech should be in the pure lower register.

Abstracts

Of Papers Presented at the Pacific Coast Convention

INTERPRETIVE abstracts of all papers presented at the Pacific Coast A. I. E. E. convention (August 25-28, 1931) are presented herewith, only excepting those papers already published in this or preceding issues of ELECTRICAL ENGINEERING. Members vitally interested and wishing to obtain immediately pamphlet copies of any of these papers are requested to use the order form appearing on p. 770 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Electric Power In the Wood-Products Industry

By C. E. Carey[1] and K. L. Howe[1]

For references to business affiliations see listing on page 756.

THIS paper deals with electric power in those industries in the Pacific Northwest which use forest wood as raw material for manufacture. It covers briefly the electric power requirements of these industries, and presents some statistics as to electric power consumption. During the past two decades the electric energy consumed in the lumber, pulp, and paper industries of this district has grown to a value comparable to the total amount generated by all of the central stations operating within the same geographic area.

General information concerning the types of motors used for various operations is given, along with some statistical information as to average power requirements for certain machines and illustrations of typical installations. The paper deals with the general application of electric power within the wood-products industry, and does not cover the technical requirements of each of the motor applications.

The methods of manufacturing within the various plants, and the requirements of the various processes determine the extent to which electric energy is used in these various mills. The success of electric power utilization is indicated, however, by an annual energy consumption of more than 2,000,000,000 kw-hr. **(A. I. E. E. Paper No. 31 M 1)**

Electrical Equipment for Oil-Field Operations

By H. C. Hill[2] and J. B. Se Legue[2]

IN THE application of electricity to the work of drilling for oil and pumping the wells, many problems peculiar to the oil industry have been encountered. This paper presents some of the more interesting features of these applications, and is confined to a discussion of the duty involved and of the design of the apparatus for the purpose. Although the petroleum industry still relies largely upon engine power, strides have been made during the past ten years in the development and application of electrical apparatus, and in the extension of central station power into oil fields. Oil companies are giving an increasing amount of attention to its use.

A comparison is made between the methods and equipment involved in cable-tool drilling and rotary drilling. Briefer consideration is given to well-pumping control equipment, electrical protection measures, and the air-gas lift. The many other uses for electric power in oil production and handling are considered as beyond the scope of this paper.

Electric power for oil-field operations was first used in the eastern fields more than 30 years ago, but the extensive use of this form of power did not begin until 10 or 12 years later, when it was introduced in the California fields. Most of the new developments which since have been made in the design and use of electrical apparatus for oil-well drilling and pumping have been tried out and perfected first in the California fields before being adopted elsewhere. This has been due not only to the field conditions encountered there, but also to the availability of dependable central station power service in all of the fields.

Of the tremendous connected horsepower in the oil industry in the United States, it is understood that only 7 per cent is electrical. In California alone there is 1,500,000 hp. installed, of which only 15 per cent is electrical. This indicates the potential possibilities for electrification. (A. I. E. E. Paper No. 31-128)

Correlation of Induction-Motor Design Factors

By Vaino Hoover[3]

AN ANALYSIS of stator resistance, wire size, horsepower rating, and air-gap density as a function of the flux per pole per unit-length of lamination stacking, stator slot shape and slot insulation, rotor diameter, and flux densities in the stator teeth and core, is given in this paper.

The usual method of design is to begin with the rotor radius, flux per pole, and ampere-conductors per inch of rotor circumference. The flux density in the air-gap is determined when the stator-tooth density and the ratio of slot pitch and tooth width are set. The depth of slot is determined by the ampere-conductors per inch, and the cir. mils per ampere. The depth of stator core and the stator radius then are determined by setting the value of the flux density in the stator core. The relations of the rotor and stator radius, the width of slot and tooth, the depth of slot and core, the flux per pole, and the flux density, to each other and to the motor performance are quite vague. Therefore, to determine their best proportions is difficult unless many experimental data are available.

In this paper an attempt is made to determine the relation of these factors to each other, and to determine their proportions for the best design. Briefly outlined, the analysis is presented as follows: The area of the stator slot is developed as a function of the shape of the slot, and the area occupied by the slot insulation. The effect of the slot insulation on the net area of the stator slot is taken into account by using a corrected value for the stator radius. The area of the wire used for stator coils is developed as a function of the flux per pole. The stator resistance is expressed as a function of flux per pole, and slot shape. The rotor radius is determined by setting the ratio of the flux densities in the core and teeth. A sample calculation is made using this method of design for motors of from two to twelve poles. The maximum torque as a function of the flux densities and of the flux per pole is discussed. The effect of stator resistance on maximum torque is calculated and shows that the flux per pole used should be very nearly that for minimum stator resistance. Fifty-three equations are developed. (A. I. E. E. Paper No. 31 M 7)

A-C. Networks in Portland, Oregon

By S. B. Clark[4]

ESSENTIALLY the full text of this paper was presented on pp. 644-647, ELECTRICAL ENGINEERING, August, 1931. (A. I. E. E. Paper No. 31 M 2)

The Mokelumne River Development of the Pacific Gas and Electric Company

By E. A. Crellin[5]

ESSENTIALLY the full text of this paper is published on pp. 705-12, of this issue of ELECTRICAL ENGINEERING. (A. I. E. E. Paper No. 31-130)

Power Transmission and Distribution from the Mokelumne River Development

By E. M. Wright[6] and B. D. Dexter[6]

ESSENTIALLY the full text of this paper is published on pp. 713-18, of this issue of ELECTRICAL ENGINEERING. (A. I. E. E. Paper No. 31-131)

Tie-Line Control of Interconnected Networks

By T. E. Purcell[6] and C. A. Powel[7]

OPERATING experience with tie-line load regulators on the Pittsburgh, Pa. tie line interconnecting the Colfax Power Station of the Duquesne Light Company with the Springdale station of the West Penn Power Company is described in this paper. Equipment used, including tie-line load regulators, program load control, and a hydraulic speed changer also is described.

The prime requirements of a successful tie-line load regulator are that it must not respond to small transient load changes, but that it must respond to small sustained changes. Further, it must respond to large load changes whether temporary or sustained.

The program loading equipment mentioned is installed at the Colfax station to maintain the most economical division of load between the various generating units of that particular station. The principle of dividing all load increments proportionally between units in a steam station does not necessarily make for maximum efficiency. In the program equipment at Colfax load scheduling is based on turbine valve position rather than on generator output, thus maintaining each turbine at its most efficient valve opening regardless of the effect of the many variables which enter into the position of the valve with reference to the load.

The new hydraulic speed-changing device described is intended to reduce to a minimum, wear on the governor parts, and to offset the tendency for increased wear arising from the extremely frequent governor operation imposed by frequency control.

As a result of tests made jointly by the Duquesne Light Company and the West Penn Power Company, the following conclusions are reached:

1. Tie-line load regulators and program loading equipment have been developed to a commercial stage.
2. Tie-line load regulators on one system can be operated satisfactorily in conjunction with frequency regulators on a connected system.
3. Tie-line control may be used to reduce load fluctuations between interconnected systems. (A.I. E. E. Paper No. 31-127)

Tuned Power Lines

By H. H. Skilling[8]

THE FULL text of this paper was published on pp. 634-37 ELECTRICAL ENGINEERING, August 1931. (A. I. E. E. Paper No. 31-124)

Intercontinental Radiotelephone Service from the United States

By J. J. Pilliod[9]

A COMPREHENSIVE abstract of this paper is published on pp. 748-52 of this issue of ELECTRICAL ENGINEERING. (A. I. E. E. Paper No. 31-129)

Electrical Solutions of Problems of Regular Scheduled Flight

By C. F. Green[10]

AN ARTICLE based on this paper was published on pp. 654-657 ELECTRICAL ENGINEERING, August 1931. (A. I. E. E. Paper No. 31 M 3)

The San Francisco-Los Angeles Section of the Pacific Coast Telephone Cable Network

By E. M. Calderwood[11] and D. F. Smith[12]

A COMPREHENSIVE abstract of this article is published on pp. 736-41 of this issue of ELECTRICAL ENGINEERING. (A. I. E. E. Paper No. 31-125)

Electrical Measurements of Sound-Absorption

By A. L. Albert[13] and W. R. Bullis[13]

PRINCIPALLY because of the recent development of high-quality radio broadcasting, group address systems, and sound motion pictures, the acoustic characteristics of buildings are now an important factor of architectural design. Using the work of Sabine and others as a basis, it is possible to design studios and auditoriums to give complete acoustic satisfaction.

However, since the sound-absorbing properties of various acoustic and building materials differ widely, it is necessary to determine quite accurately the sound-absorbing coefficients before reliable reverberation calculations can be made. These coefficients have been measured previously by various means, two of which are widely used. The first of these consists of covering the inner surface of a specially constructed room with the absorbing material to be tested. The sound-absorbing coefficients then can be calculated from the measured reverberation time. The other method is very similar except that instead of covering the surface of a room with the absorbing material, the material is placed on large panels in the room. Both of these methods as well as others which have been devised are accurate but necessitate the use of large test samples and are somewhat slow and expensive in use.

This paper describes an electrical method of measuring the sound-absorption properties of acoustic materials. Both the equipment and method can be said to be simple and rapid in operation, and inexpensive. With this method, the sound absorbing properties are determined by the effect produced on the electrical characteristics of a loud speaker by sound waves reflected from the absorbing material. The test equipment includes a relatively small wooden tube inside of which a loudspeaker with a special mounting may be moved back and forth with respect to the end of the box in which is mounted the sound-absorbing material to be measured. In addition to this equipment there is simply a vacuum-tube oscillator with bridge measuring arrangement including the loudspeaker coil in one side of the bridge circuit.

Advantage is taken of the generally known fact that the electrical impedance measured between the terminals of a telephone receiver or loudspeaker is greatly affected by the location of the device with respect to reflecting surfaces in front of it. The effects of various sound-absorbing materials, as reflected through the adjustable loudspeaker device, are translated through the bridge readings into comparable figures which reveal the relative characteristics of different samples of materials. Although the tests which have been made and which are described in the paper indicate that this method gives consistent results, it is believed that the device can be made even more satisfactory and perhaps arranged to give the sound-absorbing coefficients directly as an indicating-instrument reading rather than from the impedance-bridge settings. (A. I. E. E. Paper No. 31 M 6)

Cathode Drop in Arcs and Glow Discharges

By S. S. Mackeown[3]

THE ARC is defined as an electrical discharge in a gas or a vapor in which the cathode drop is of the order of 10 or 20 volts and the current density to the cathode spot is of the order of hundreds or thousands of amperes per square centimeter. For an arc to exist it is necessary that there be some mechanism for producing electrons at or near the cathode. Unfortunately, there is no general agreement among physicists as to the mechanism which produces this low cathode drop with the correspondingly high current density which is characteristic of an electric arc. In this paper the author reviews briefly the different prevalent theories regarding the low cathode drop in an arc, offering discussions and interpretations based upon extensive research work carried out at the California Institute of Technology.

The author divides his subject treatment into four general parts: (1) the cathode drop in an arc, (2) the normal cathode drop in a glow discharge, (3) the abnormal cathode drop, and (4) transition from a glow discharge to an arc. In each case prevalent theories are briefly presented and discussed. (A. I. E. E. Paper No. 31 M 5)

The Kindling of Electric Sparkover Based on Lichtenberg Figures

By C. E. Magnusson[14]

THE MECHANISM of the electric sparkover process lately has become a much discussed problem. Townsend's theory of the formation of electric sparkover has been challenged and at least in some respects found wanting. Several well-known investigators have given ample evidence that the sparkover process is very complex; that the speed of formation is in the order of 10^8 cm. per sec. instead of 10^4 or 10^5; that polarity and shape of electrodes, ionization, space charges, voltage gradients air pressure, temperature, and other factors enter into the problem. The results of investigations on the early stages of electric sparkover throw light on certain phases of the initial or kindling stage of an electric spark formation, but a comprehensive explanation of the mechanism or process involved in the formation of electric sparks or sparkover still is lacking.

In this paper a new method of approach is described and experimental evidence is presented which tends to show that for *impulse sparkover* the following statements are valid:

1. Electrons are primarily the active elements in the kindling mechanism.
2. Lichtenberg figures form the initial step in the kindling process.
3. Sparkover develops from the tips of the positive Lichtenberg figures along the streamers of both the positive and the negative figures. (A. I. E. E. Paper No. 31-123)

Snow Surveys and Hydro-Forecasting

By H. P. Boardman[15]

A COMPREHENSIVE description of the apparatus and methods involved in a cooperative precipitation survey and the results obtained are given in this paper. The scope of the paper is limited principally to the watershed area of the eastern Sierra Nevada range of California, the runoff from which constitutes the chief source of water supply for Reno, Nevada, and environs. Statistical information is presented which reveals the accuracy of predictions based on snow surveys, as compared with actual runoff for various seasons. (A. I. E. E. Paper No. 81 M 4)

Radio Coordination

By C. C. Campbell[5] and H. N. Kalb[16]

THE AUTHORS' experience with radio-interference problems in northern and central California is used as a basis for this paper. An attempt has been made to present the various phases of the problem rather than to offer a solution of any particular phase. Radio interference from natural static and from radio sources is not within the scope of this paper, but is mentioned where it has a bearing upon interference caused by electrical sources. Natural static is less severe in the West than in the East, making other types of radio interference more apparent. A larger network of higher voltage transmission lines also has been built up in the West because of the extensive hydro-electric developments and a more scattered population, and this factor also enters the problem to some extent.

Variations of broadcast service area arising from station power and location and as affected by the topography of the surrounding country have been found to have an important bearing upon the radio-interference problem. Experience shows that there is no simple solution for the interference problem; that it must be dealt with in a spirit of cooperation by the utilities, the electric manufacturers, and the public. In the West, interference from electric power supply systems is well in hand except for the troubles originating on high-voltage lines. Although filters on power lines have been suggested, their use is questionable.

Manufacturers have a great opportunity in the sale of radio noiseproof appliances and apparatus, and the public can help by insisting upon such appliances. Increased broadcast coverage is very desirable to offset the maximum noise level in many of the large areas now having low field strengths. However, continued cooperative effort on the part of all concerned undoubtedly is the best solution to the interference problem. (A. I. E. E. Paper No. 31-122)

Calorimeter Measurement of Stray-Load Losses

By G. D. Floyd[17] and J. R. Dunbar[18]

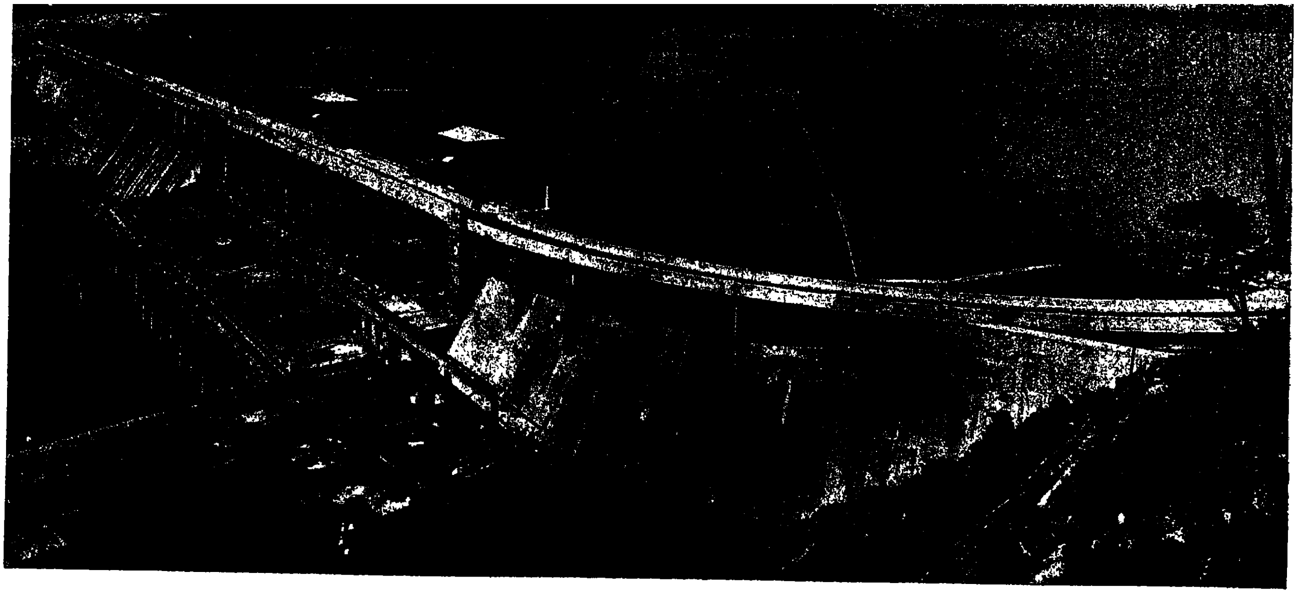
THIS paper covers several thermal or calorimeter tests which were made at the Queenston generating station of the Hydro-Electric Power Commission of Ontario, on a 55,000-kva. generator having an enclosed system of ventilation. The objects of the tests were to determine stray-load losses on short circuits and under rated load, and to obtain some information regarding the accuracy of this method of test. Descriptions are given covering the general method followed and the actual tests as made. For those who might wish to check the calculations in detail the actual figures are given in an appendix.

The results of the tests show that the stray-load losses on large units can be determined with fair accuracy by this method when an enclosed system of ventilation is used on the unit. Tests also seem to show that the difference between the stray-load losses under load conditions and under short-circuit conditions is slight, and that a test under load conditions is justified only when an extremely accurate determination of losses is required. For most purposes a test under short-circuit conditions seems to be sufficient. (A. I. E. E. Paper No. 31-126)

Business Affiliations of Authors

1. Westinghouse Elec. & Mfg. Co., Seattle, Wash.
2. General Electric Co., Los Angeles, Calif.
3. California Institute of Technology, Pasadena.
4. Northwestern Electric Co., Portland, Oregon.
5. Pacific Gas and Electric Co., San Francisco, Calif.
6. Duquesne Light Co., Pittsburgh, Pa.
7. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
8. Stanford University, Calif.
9. American Tel. & Tel. Co., New York, N. Y.
10. General Electric Co., Schenectady, N. Y.
11. Pacific Tel. & Tel. Co., San Francisco, Calif.
12. So. Calif. Telephone Co., Los Angeles, Calif.
13. Oregon State College, Corvallis, Oregon.
14. University of Washington, Seattle, Wash.
15. University of Nevada, Reno, Nevada.
16. San Joaquin Light and Power Corp., Fresno, Calif.
17. Hydro-Electric Power Commission of Ontario, Toronto, Ont.
18. Canadian Westinghouse Co., Ltd., Hamilton, Ont.

News
Of Institute and Related Activities



Bagnell dam and semi-outdoor power house of the Union Electric Light and Power Company (St. Louis) built by Stone & Webster Engineering Corporation

South West District To Meet at Kansas City

A VARIETY of interesting technical subjects, good entertainment and profitable inspection trips to noteworthy local engineering projects comprise the program for a three-day fall meeting of the South West District No. 7 to be held at Kansas City, Mo., Oct. 22-24, 1931. Headquarters will be at the Kansas City Athletic Club.

Nineteen papers will be presented in four technical sessions the first of which consists of a group of selected subjects: back-fires in rectifiers, surge tests on a distribution substation, overvoltages due to dropping of load, computing currents in networks and loops, building-construction welding, effect of wave form on relay operation, and pilot-wire relaying. The second session will be devoted to the St. Louis-Bagnell interconnection, with the showing of a motion picture description of the actual construction of the Bagnell dam. The third session will deal with communication subjects; economic surveys, advance planning of long distance telephone facilities, tape-armored cable, and the time factor in transmission. The closing session will be on subjects in the field of transmission and distribution, such as lightning field investigation, heat flow from cables, corona energy loss, fuses, and cut-outs.

The banquet Friday evening, October 23, will be held in one of the finest banquet rooms in the Middle West—that at the Kansas City Athletic Club, noted for its excellent cuisine. Between courses, entertainment will be provided by some of the best talent obtainable, and following the banquet there will be dancing with music furnished by an orchestra well qualified to please all.

Golf will be arranged for all those who may wish to play.

WOMEN'S ENTERTAINMENT

Women attending will be entertained with a luncheon bridge at one of our golf clubs, a theater party, and shopping tours. Nothing will be left undone to mak their visit to Kansas City a pleasant one.

Tentative Program

Thursday—a. m.

Registration

Opening address

Student technical session

Thursday—p. m.

(a) **Student Session**

(b) **Session on Selected Subjects**

Electric Arc Welding in Building Construction, P. N. Vinther, Dallas Power & Light Co.

The Effect of Wave Form on the Operation of Induction-Type Relays, P. H. Robinson, Houston Lighting & Power Co.

The Telegraphic Pilot-Wire Relay System, O. H. Frier, Oklahoma Gas & Electric Co.

Calculating Load Division in Distribution Systems, C. T. Almquist, The University of Oklahoma.

Back-fires in Mercury-Arc Rectifiers, J. Slepian and L. R. Ludwig, Westinghouse Elec. & Mfg. Co.

Overvoltages on Transmission Systems due to Dropping of Load, E. J. Burnham, General Electric Co.

Impulse-Voltage Tests on a 4,800-Volt Distribution Substation, H. W. Collins and E. E. Piepho, Detroit Edison Co., and J. J. Torok, Westinghouse Elec. & Mfg. Co.

Thursday Evening

St. Louis-Bagnell Interconnection

Interconnection of the 25- and 60-cycle Systems of the Union Electric Light & Power Co., E. L. Hough and L. V. Nelson, Union Elec. Light & Power Co.

Automatic Control for Variable-Ratio Frequency Converters, E. K. Shively, Union Electric Light & Power Co., and G. S. Whitlow, General Electric Co.

Three-Reel Motion Picture of the Actual Construction of the Bagnell Dam.

Friday—a. m.

Communication

Economic Surveys and Their Application to Engineering Problems, J. N. Holsen, Southwestern Bell Tel. Co.

Advance Planning of Long Distance Telephone Facilities, O. C. McFarland, Southwestern Bell Tel. Co.

Tape-Armored Telephone Toll Cable, C. W. Nystrom, Southwestern Bell Tel. Co.

The Time Factor in Telephone Transmission, O. B. Blackwell, American Telephone & Telegraph Co.

Friday—p. m.

Inspection trips and recreation

Meeting of board of directors

Friday Evening

Banquet and entertainment

Saturday—a. m.

Transmission and Distribution

Field Investigation of Lightning Disturbances on Transmission Lines, D. C. Jackson, Jr. and R. W. Warner, University of Kansas.

Heat Flow from Underground Electric Power Cables, L. J. Neuman, The Texas Co.

Corona Energy Loss, W. D. Weidlein, Black and Veatch.

Application of Primary Distribution Fuses, F. E. Sanford, Union Gas & Electric Co.

The Expulsion Fuse, J. Slepian and C. L. Denault, Westinghouse Elec. & Mfg. Co.

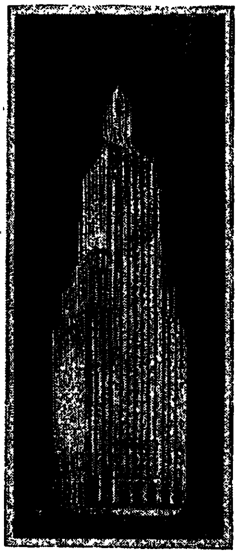
Fuse Cut-outs with Special Reference to Their Design and Application for A-C. Distribution Circuits, E. G. Newton, General Electric Co.

Saturday—p. m.

Inspection trips and recreation

Hotel Reservations

Reservations for hotel rooms should be made by writing directly to the hotel preferred. In the following table, rates are listed for the headquarters hotel, the Kansas City Athletic Club, and several other hotels conveniently located in the neighboring vicinity. Members of the Dallas, Houston, Oklahoma City, and Wichita Athletic Clubs may enjoy reciprocal relations:



New building of the Kansas City Power & Light Company features a 13,200/199/115-volt, three-phase, four-wire, vertical distribution system

Hotel	Hotel Rates Single Rooms	 Double Rooms
Kansas City Athletic Club	$3.00-$5.00	$5.00-$7.00
Baltimore	$1.50-$2.00*	$2.50-$3.00*
	$2.50-$5.00	$3.50-$6.00
Muehlebach	$2.50-$3.50*	$4.00-$5.00*
	$3.50-$8.00	$5.00-10.00
Phillips	$2.50-$4.00	$4.00-$6.00
Pickwick	$2.50-$4.00	$3.50-$6.00
President	$3.00	$5.00
Stats	$2.00-$3.50	$2.50-$5.50

*Rooms without bath

Committees

The personnel of the general committee consists of: G. C. Shaad, *chairman*, vice-president South West District; R. W. Warner, secretary South West District; S. T. Blaisdell; J. E. Busher; C. B. Fall; C. D. Farman; D. C. Jackson, Jr.; F. J. Meyer; J. S. Palmer; A. A. Rall. Subcommittee chairmen are: R. L. Baldwin, *hotels and registration*; M. M. Boggess, *finance*; D. D. Clarke, *technical sessions*; D. W. Ellyson, *golf*; G. Fiske, *entertainment*; A. L. Maillard, *inspection trips*; O. P. Minnick, *publicity and attendance*; F. L. Phillips, *transportation*; M. P. Weinbach, *student activities*.

Inspection Trips

Kansas City is the home of nearly every type of industry that can hold the attention of an engineer, especially electrical engineers. Some interesting features to be studied are the new supersynchronous motor installations for the cement mills, the completely automatic system of the Kansas City Power & Light Company, the application of electricity to the milling industry, for example the new automatic installations of the Southwestern Bell Telephone Company. Engineers interested in the application of electricity to water supply systems also will find Kansas City a capital place to study.

Grand Avenue Station

In 1927, the Kansas City Power & Light Company acquired the old Grand Avenue Station of the Kansas City Public Service Company (the street railway company). This plant which was first put in service in 1903 was antiquated and expensive to operate; however, the location made it not only favorable for central power production and distribution, but ideal as a production center for the continually increasing demand for central district steam heat. Upon the acquisition of this property, a rebuilding program was started which has extended over a four-year period and has involved the expenditure of nearly $6,000,000. The result has been the conversion of an obsolete inefficient station into a strictly modern, efficient, high-pressure power and heating plant. All central station men will want to review this rebuilt work and see how increased efficiency was brought about in so short a time.

Other Points of Interest

In addition to its two generating stations, Kansas City for its size probably has the most complete automatic power distribution system of any city in the United States, with all power except for 13.2-kv. primary service supplied from substations equipped with complete automatic control. The system consists of two major parts: the d-c. substations, and city a-c. substations with outdoor a-c. suburban stations.

The d-c. system embraces a restricted district in the downtown business section, with d-c. network fed from five synchronous converter substations of two automatically controlled machines, each of which feeds an individual bus, being tied together only through the d-c. network.

The a-c. system consists of seven 13,200/4,400/2,550Y-volt, three-phase, four-wire automatic substations. These stations located in various parts of the city are architecturally designed to conform to the type of district in which they are located. Interior designs follow usual practise, but with such additional features as comply with latest ideas. Stations of interest in this group are: Substation *R* of residential type using reinforced concrete for switch barriers and regulator bays; Substation *A* of residential type using "Ha-dite" concrete barriers; and the latest Substation *H* located in a newly developed business and apartment district, with the station exterior designed to conform with the general architectural plan of the district. The interior design is in artistic agreement with the exterior. Special features of this station include switch structures and regulator bays of fabricated stone, all circuit breakers frame-mounted and not supported by the barriers, and a heating and ventilating system fully automatic in its operation.

A visit to the Bell Telephone building will afford an opportunity to inspect a large telephone power plant, a large telegraph repeater station, a panel-type dial central office, a large manual central office, toll and local operating rooms, etc. The Benton-Chestnut exchange which is to go into operation October 1, 1931 has the most modern type of dial equipment, together with associated operators' positions. This exchange has 16,500 terminal stations with an average of 120,000 originating and 117,000 incoming calls per day.

The committee has arranged a trip to the Bagnell water power project of the Union Electric Light & Power Company located in the center of the state. This trip, in addition to the fine papers on this subject, will give an interesting picture of this much discussed project.

Radio Newspaper.—A daily newspaper, specially prepared for radio facsimile transmission by the Schenectady *Union Star*, has been sent daily to ships at sea from General Electric's short wave station at Schenectady, N. Y., since July 30. The newspaper is compiled late in the afternoon to contain the latest news of the day, and is transmitted between 9 and 11 o'clock at night over apparatus developed by Dr. E. F. W. Alexanderson (F'20). At present reception of this radio newspaper is limited. Receivers have been installed by the Radio Marine Corporation on two transatlantic liners, the *America*, and the *Minnikahda*, and another is being operated in Doctor Alexanderson's department in the General Electric research laboratory, about 3 mi. from the transmitter. The receivers are known as the carbon facsimile recorders, developed a year or two ago by Charles J. Young, son of Owen D. Young.

Tahoe Convention To Be Reported

The Pacific Coast convention at Lake Tahoe, California, opened its sessions Tuesday morning, August 25, too late to be reported in this issue of ELECTRICAL ENGINEERING. However, brief interpretative abstracts of all Tahoe papers may be found on pp. 753-56 of this issue.

The general news story covering convention activities will appear in the October issue. It is hoped also that the written discussion of Lake Tahoe papers will be in the hands of the secretary of the meetings and papers committee at 33 West 39th Street, New York, N. Y., in sufficient time and in sufficient quantity to warrant the presentation of a review of discussion in connection with the convention story in the October issue.

Directors Meet at Institute Headquarters

The regular meeting of the A. I. E. E. board of directors was held at Institute headquarters, New York, August 4, 1931. Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Vice-presidents*—H. P. Charlesworth, New York, N. Y.; L. B. Chubbuck, Hamilton, Ont.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; I. E. Moultrop, Boston, Mass.; G. C. Shaad, Lawrence, Kans. *Directors*—A. B. Cooper, Toronto, Ont.; J. E. Kearns, Chicago, Ill.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; C. E. Stephens, New York, N. Y. *National treasurer*—W. I. Slichter, New York, N. Y. *National secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of June 24, 1931, were approved.

Approval was given to a report of a meeting of the board of examiners held July 29, 1931; and upon the recommendation of that board, the following actions were taken upon applications pending: 18 Students were enrolled; 51 Associates were elected; seven Members were elected; 23 applicants were transferred to the grade of Member and two to the grade of Fellow.

Approval for payment by the finance committee of monthly bills amounting to $38,414.61 was ratified.

Authorization was given for the extension of territory of the Los Angeles and the San Francisco Sections in order to include the entire state of California between the two Sections.

The president announced the appointment of committees and representatives for the administrative year beginning August 1, 1931. (A list of committees and representatives appears elsewhere in this issue.)

As required by the by-laws of the Edison Medal committee, the board confirmed appointments to the committee made by the president as follows: D. C. Jackson, chairman for the year beginning August 1; E. B. Meyer, L. T. Robinson, and P. H. Thomas, for terms of five years each; C. E. Stephens to fill vacancy for the year ending July 31, 1932. Also, the board elected from its own membership to serve on the committee for terms of two years each, J. E. Kearns, W. S. Lee, and F. W. Peek, Jr.

In accordance with the by-laws of the Lamme Medal committee, the board confirmed the following appointments by the president: B. A. Behrend, A. M. Dudley, and J. C. Parker.

Local honorary secretaries reappointed for the two-year term beginning August 1, 1931, were: M. A. Chatelain, Russia; A. F. Enstrom, Sweden; A. P. M. Fleming, England; T. J. Fleming, Argentina; Renzo Norsa, Italy; P. H. Powell, New Zealand; F. M. Servos, Brazil.

Upon the recommendation of the standards committee, various subjects were referred for consideration to the electrical standards committee of the American Standards Association, and approval was given for publication as a report of the committee on electrical machinery for further study by those interested, of a proposed test code for transformers prepared by the electrical machinery committee.

Progress report No. 7 of the joint committee on welded rail joints, submitted by D. D. Ewing, A. I. E. E. representative on the committee, was received and ordered filed in the Engineering Societies Library.

The board voted to hold its next meeting in Kansas City, Mo., during the District meeting to be held in that city, October 22-24.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

At Asheville - - - in 1905

IN this group in attendance at the Institute's 22nd annual convention held at Asheville, N. C., June 19-23, 1905, were five some-time presidents of the Institute: T. Commerford Martin, 1887-8; Charles P. Steinmetz, 1901-2; John W. Lieb, 1904-5; Samuel Sheldon, 1906-7; and C. O. Mailloux, 1913-14. Of all these, Doctor Mailloux is the only one now living.

Faraday Centennial to be Held in London

TO COMMEMORATE the one hundredth anniversary of the discovery of electromagnetic induction in 1831 by Michael Faraday, who, blacksmith's son though he was, has come to be known as the "creator of the age of electrical power," the Royal Institution and the Institution of Electrical Engineers of London, in cooperation with other British scientific societies, are arranging a centenary celebration to be held September 21-23, 1931. Government and university bodies as well as other scientific interests also have joined hands in offering their cooperation and assistance to make the celebration worthy of the occasion.

The following tentative program has been announced by the institutions sponsoring the celebration:

Monday, September 21

Afternoon

Reception of delegates from representative institutions throughout the world in the lecture theater of the Royal Institution.

Evening

Faraday commemorative meeting at Queen's Hall during which addresses will be given on Faraday's work.

Tuesday, September 22

Morning

Summer meeting of the Institution of Electrical Engineers begins with joint conference of the Institution and allied associations.

Afternoon

Visits and social functions.

Evening

Royal Institution: Conversazione at the House of Institution.

Institution of Electrical Engineers: Conversazione and Faraday exhibition at the Albert Hall.

Wednesday, September 23

Morning

Opening of the Faraday exhibition to the public. I. E. E. summer meeting and conference continued.

Evening

Opening meeting of the British Assosociation at the Central Hall, Westminster.

Honoring Faraday and his work, the program on Monday evening will include tributes by the British Prime Minister, the Rt. Hon. J. Ramsay MacDonald, the Duc de Broglie, Senator Marconi, Prof. Elihu Thomson, Prof. P. Zeeman, and other distinguished representatives of leading institutions throughout the world. The most outstanding feature of Monday night's program, however, will be the commemoration address by Sir William Bragg, who is one of Faraday's successors as head of the Royal Institution in London where the majority of the great scientist's experiments were carried out.

The entire commemorative meeting of Monday evening will be broadcast in England by the British Broadcasting Corp., while in the United States the National Broadcasting Company will rebroadcast a portion of the program between 4:00 and 5:00 p. m. eastern daylight saving time.

The exhibition to be opened on Wednesday has been arranged principally by the Institution of Electrical Engineers, and will be open to the public for a period of about ten days. The central feature of this exhibition will be reproductions and illustrations of Faraday's actual experiments, prepared by the Royal Institution, together with a display of some of his historic apparatus. Faraday's chemical and electrochemical work, which while not so well known as his discovery of electromagnetic induction nevertheless is hardly less remarkable, will be illustrated by means of special exhibits arranged by other cooperating societies.

Upon invitation of both the Royal Institution and the Institution of Electrical Engineers, the A. I. E. E. has appointed Dr. Wm. McClellan (F'12 and past-president) as its delegate to the celebration, and Dr. A. E. Kennelly (F'13 and past-president) as alternate.

Preceding the Wednesday morning opening of the Faraday exhibition, General Smuts, recently elected head of the British Association for the Advancement of Science, will deliver an address. On behalf of the other American societies who were invited to participate, Dr. F. B. Jewett (F'12 and past-president) then is scheduled to deliver brief felicitations by radiotelephone.

FARADAY'S DIARY TO BE PUBLISHED

Among the other many interesting features of the celebration comes the announcement of the publication of Faraday's diary, two volumes or more of which are expected to be ready by the time the celebration takes place. Faraday maintained a careful diary of all of his experimental work and this has been bequeathed to the Royal Institution and for over 60 years has been that organization's treasured possession. Although Faraday made extensive use of his notes in the preparation of his published works, the diary itself never has been published. As a permanent memento of the centenary celebration as well as of the man himself, managers of the Royal Institution have resolved to publish it in full.

Valuable Trophies Won in Summer Convention Sports

HEADLINER among the attractive sporting events offered at Asheville in connection with the annual summer convention of the Institute, June 22-26, 1931, was the annual tournament for the Mershon cup. Of chief interest in this connection is the fact that L. F. Deming (A'17) district engineer of the General Electric Company at Philadelphia, Pa., came into permanent possession of the Mershon trophy by virtue of his second winning of it. Mr. Deming won the first right to have his name engraved on the cup at the annual tournament held in connection with the summer convention at Cleveland, Ohio, in 1916. A beautiful silver tray also was presented to Mr. Deming as 1931 tournament winner by the Asheville convention sports committee. As runner-up in the Mershon tournament, R. O. Bentley (M'14) superintendent of the Public Service Electric & Gas Company, Newark, N. J., was presented with a beautiful silver bowl.

A silver bowl also was presented to S. K. Bushnell (A'22) Philadelphia sales manager for the Aluminum Company of America, for achieving low gross of 77 (par 71) in the qualifying round. A. H. Sweetnam (M'18) superintendent of the electrical engineering department of the Edison Electric Illuminating Company, Boston, also won a silver bowl for his low net of 60 (80-20) in the qualifying round.

In connection with the second round of the Mershon Cup event, a silver bowl was won by E. W. Dillard (A'16-M'30) electrical engineer for the New England Power Association, Boston, for his happy choice of 76 as a kicker's handicap (100-24). Tied with Mr. Dillard so far as net scores in this event were concerned, were R. A. Monroe (A'30) hydraulic engineer for the Aluminum Company of America, Pittsburgh, and G. A. Kositzky (M'22-F'29) chief engineer of the Ohio Bell Telephone Company, Cleveland. The prize was awarded by lot to Mr. Dillard.

For medal play handicap, two silver bowls were awarded, one to H. C. Don Carlos (F'18) chief operating engineer for the Hydro-Electric Power Commission of Ontario, Toronto, for his low gross of 82; and one to R. A. Monroe for his low net of 69 (84-15).

In the ladies' putting contest held on the 18-hole lawn course of the Grove Park Inn at Asheville, Mrs. W. K. Vanderpoel of South Orange, N. J., won first place and received a pair of silver bowls. As runner-up, Mrs. A. E. Bettis of Kansas City, Mo., won a silver plate.

In men's singles at tennis, J. K. Peck (A'27) assistant engineer for the National Electric Light Association, New York, came out best man receiving a silver bowl as his prize. As runner-up, E. F. Lopez (A'16-M'18) manager of the National Import Company, Mexico City, won a set of six silver ash trays.

Winners of Mershon Trophy

A. M. Schoen	1912
J. C. Mock	1914
E. W. Allen	1915
L. F. Deming*	1916
A. A. Brown	1919
M. G. Kennedy	1920
Howard Maxwell	1921
Philip H. Chase	1922
G. L. Knight	1923
R. O. Bentley	1924
C. E. Stephens	1925
H. C. Don Carlos	1926
A. H. Sweetnam	1927
W. C. Heston	1928
W. S. Lee	1929
Wills Maclachlan	1930
L. F. Deming*	1931

*Permanent possession gained by virtue of second winning.

Illumination Engineers Meet in October

The twenty-fifth annual convention of the Illuminating Engineering Society will be held at the William Penn Hotel, Pittsburgh, Oct. 12-16. Indications are that this convention will attract wide attention, several unusual additions having been made to the technical program, according to official announcement. There will be also a special program commemorating the society's silver anniversary.

Recognizing the present day importance of safety in night flying, the society has given over an entire session to the discussion of aviation lighting. Central-station lighting also will be given an important place on the program.

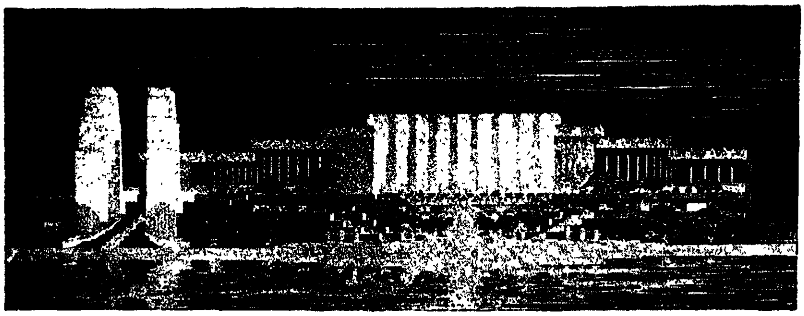
A. W. Robertson (A'27) chairman of the board of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, is chairman of the general convention committee, and J. A. Hoeveler of the Pittsburgh Reflector Company is chairman of the convention executive committee; P. H. Powers (M'30) vice-president of the West Penn Power Company and Joseph McKinley, vice-president of the Duquesne Light Company are serving as vice-chairmen. The committees in charge invite early registration by all who expect to attend.

Polish Engineering Secretary Visits U. S.

Joseph Podoski, secretary-general of the Polish Association of Electrical Engineers, spent the first two weeks of August touring the eastern portion of the United States in the interests of his organization. Mr. Podoski spent appreciable time acquainting himself with the policies and operating procedure of the American Institute of Electrical Engineers and the American Standards Association; he was interested also in electric power problems and railway electrification, spending several days visiting manufacturing plants and operating properties in an effort to gain a first-hand impression of American technique.

Mr. Podoski is one of the first Polish engineers to visit the United States under the reciprocal visiting membership privileges provided by action of the board of directors several years ago and recently extended to include the Polish Association of Electrical Engineers. Under this arrangement Institute headquarters in New York receives and forwards mail, upon presentation of proper credentials provides letters of

"A Century of Progress" Electrical Group



GROUND was broken Monday, July 20, 1931, for the Electrical Group, fifth building of Chicago's 1933 World Fair. The building was designed by Raymond Hood of New York, is 1,200 by 300 ft. in plan, two stories high, and of striking modernistic design employing a combination steel and special wallboard exterior; white, yellow, red, black, and blue are to be dominant colors. This structure will be embellished with hanging gardens and paved terraces, and will provide generous areas for the exhibition of generation, distribution, utilization, and communication equipment.

---

introduction, affords a convenient meeting place for appointments, and places at the disposal of foreign engineers the resources of the Engineering Societies Library. Normally, these privileges are available for a period of three months, but are subject to extension for cause. Under the recently established arrangement members of the A. I. E. E. visiting Poland will receive full privileges from the Polish organization providing formal application is made through Institute headquarters in New York.

A. C. Langmuir Prize in Chemical Research Awarded

Dr. Linus Pauling, who at thirty has published nearly fifty papers in the field of pure science, and has won a full professorship in the California Institute of Technology, has been chosen as the first winner of the A. C. Langmuir prize of the American Chemical Society. The work of Pauling who will receive the award at the eighty-second meeting of the Society at Buffalo, September 2, has had to do with crystal structure, the quantum theory of the dielectric constant of gases, atomic and molecular structure, and determination of the nature of chemical bonds.

The Langmuir Prize, awarded for the first time this year, is bestowed "in recognition of the accomplishment, in America, of outstanding chemical research by a young man or woman preferably working in a college or university." It emphasizes, according to the announcement, the debt industry owes to pure science. "Outstanding chemical research for the purposes of the award," it stipulates, "is that which is of unusual merit for an individual on the threshold of his career in chemistry."

Dr. A. C. Langmuir, brother of Dr. Irving Langmuir, noted scientist of the General Electric Company, is an industrial chemist, teacher, and author, whose principal researches have dealt with shellac and glycerine. He first became interested in chemistry while a student at Irving Institute, Tarrytown-on-Hudson, setting up a small laboratory in his home. His experiments attracted the curiosity of his younger brother, who, with this as a starting point, has won worldwide fame in electrical research.

Secret Ray Light Applies Train Brakes.—An automatic stop system for trains, invented by Major Raymond Phillips of England, enables a person on the ground to apply the brakes and stop the train. All the person on the ground needs is a hand lamp that works a secret ray. When this light is thrown on an oncoming engine the ray works a special form of light-cell switch which applies the engine's vacuum brakes.—*Telegraph & Telephone Age, July 16, 1931.*

Photoelectric Cell Controls Street Lights

In Albany, N. Y., nine street lighting circuits are turned on automatically as soon as a certain predetermined degree of darkness occurs, regardless of the hour of the day. The photoelectric device which provides this automatic control is mounted on the roof of the Albany service building of the New York Power and Light Corporation, and is one of the first such control units to be placed in commercial service. As long as the predetermined degree of darkness prevails the device keeps the street lights in service, cutting them off upon the advent of sufficient daylight.

According to the General Electric Company "ultimately all the street-lighting circuits in the city will be operated by similar equipment . . . "

It is claimed that the photoelectric-tube device is more flexible and positive in operation than are time switches or manual operation. For example, during the 97 per cent total eclipse of the sun expected in 1932 Albany street lights probably may be expected to turn on automatically, as they also may upon very dark and stormy days. Further, seasonal changes will be taken care of automatically.

Arthur Wright, noted English consulting engineer and a pioneer in meter engineering, died in England, July 28, 1931, at the age of 73. A native of London, the first plan for him was to enter the medical profession; but he deviated from this course to take up electrical engineering, and as the first electrical engineer for the Brighton Town Council, installed the Portslade generating station. He was well-known in this country, visiting twice each year to instruct the employes of the Edison Electric Illuminating Company, Boston, in the latest developments of European engineering. As representative of the United States National Committee of the International Electrotechnical Commission, he attended the London meeting (1929) and the Stockholm meeting (1930) of Advisory Committee No. 2. Until six months ago, when his health failed, he was a member of the Institute which he joined in 1906 as an Associate.

Homer Eldredge Niesz, manager of industrial relations and vice-president of the Commonwealth Edison Company, Chicago, president of the National Safety Council and a member of its executive committee, died August 7, 1931, of peritonitis. He was 63 yr. of age.

Airplanes Carry South American Freight

A fleet of three G-31 Junkers planes of the Guinea Airways is reported as having been chartered primarily by the Bulolo Gold Dredging, Ltd., for hauling heavy mining equipment and supplies from the coast to their relatively inaccessible gold mines, and to carry back for export the precious metal itself. Each plane uses three 450-hp. air-cooled Bristol-Jupiter engines, giving a full-load speed of 115 mi. per hr. On a trial flight one of these planes carrying a 3.5-ton load of freight plus a crew of three and fuel sufficient for flight of 1½ hr., climbed 7,500 ft. in 11 min. With one side engine cut out, the loaded freighter in 2 min. gained nearly 500 ft. of elevation.

Bucket dredges equipped with eighteen Westinghouse motors ranging in size up to 200 hp. each, switching equipment, and 200-kw. transformers are typical of equipment that has been flown the 32 mi. inland to the British New Guinea gold fields. Much shorter than the former circuitous water route, the air line hurdles mountains more than 2 mi. high.

American Engineering Council

Oil Pollution of Water Reported on Decline

Pollution by oil of coastal and inland waters in the United States is declining, it is indicated in a recent report of the American Engineering Council's joint committee on oil pollution.

Legislation to extend federal jurisdiction over waters which are under state control is opposed by the committee, of which Robert S. Weston of Boston, representing the American Society of Civil Engineers, is chairman.

"In reviewing the general problem of pollution by oil," the report declares, "the committee quite frequently has been confronted with the fact that one of the principal offenders in this connection is the United States Navy, which it is reported discharges oil from oil-burning warships without much regard for state or federal rules."

Replies to a questionnaire sent to sanitary engineers in 44 states show that pollution is believed to be decreasing in 25 states, and increasing in eleven. In six states the question was regarded with doubt. Of greater importance to the committee, however, is the fact that in 26 states the present state machinery was thought to be adequate to control the situation. In only twelve states was it felt that this machinery was inadequate.

House and Senate bills to enlarge federal authority are characterized by the committee as "most undesirable." These measures make it unlawful for any person to discharge oil by any means into or upon navigable waters, or upon any of the Great Lakes, their harbors or their connecting channels. Penalties are provided for violation of the law, the administration of which would be placed in the War Department.

Other members of the American Engineering Council's oil pollution committee, which was organized by G. T. Seabury of New York, secretary of the American Society of Civil Engineers, are: Abel Wolman, Baltimore, chief engineer of the Maryland State Department of Health, representing the American Society of Civil Engineers, secretary; W. H. Gartley, vice-president of the Philadelphia Gas Works Company, and W. C. Morris, New York, vice-president of the Consolidated Gas Company, the American Society of Mechanical Engineers; C. V. Weston, consulting engineer of the Chicago Surface Lines, and J. William Wetter, manager of Madeira Hill and Company, Philipsburg, Pa., the American Institute of Mining and Metallurgical Engineers; Dr. H. C. Parmelee, New York, editor of *Engineering News-Record*, and A. E. Marshall, Corning (N. Y.) Glass Company, American Institute of Chemical Engineers.

Personal

H. L. Doherty (F'13) according to recent disclosure through the columns of the society weekly, *Cleveland Town Tidings* (July 18, 1931) was the one who made financially possible the first floodlighting of the Statue of Liberty. George Williams, well remembered figure at Nela Park, conceived the plan and proposed it to the New York *World* which promptly approached Mr. Doherty, then associated with Mr. Williams, to underwrite the undertaking and promise to make good any deficit which might exist after all contributions were in. The *World* itself headed the list with $1,000 and 80,000 persons subscribed to the cause; not, however, until Mr. Doherty's promise of financial support had been obtained. The amount for which he ultimately gave his own check amounted to several thousand dollars. His part in the plan was pledged to obscurity, and neither his nor Mr. Williams's names were to appear in any publicity of the scheme. Since 1916 the true facts have remained a secret. Mr. Doherty's advance in the world of finances presents an interesting history. A news boy in the city of Columbus, Ohio, at the age of ten, he deserted that source of revenue two years later to become an office boy. By the time he was twenty he was manager of a public utility, and at thirty-five was a recognized leader in utility engineering and finance.

C. L. Dawes (M'15) has been advanced from the rank of assistant professor of electrical engineering to associate professor at Harvard University. Mr. Dawes has done much valuable research work in the insulation field, contributing considerable to technical literature in series of articles "Ionization Studies in Paper-Insulated Cables" and others. He has held office on the N. E. L. A. cable research committee and the A. I. E. E. committee on dielectrics and subcommittee on definitions and terminology; is student counsellor and was a member of the A. I. E. E. committee on student Branches. He is a member of the National Research Council.

T. R. Langan (M'30) who has been assistant manager of the northeastern district of the Westinghouse Electric & Manufacturing Company, now has been appointed manager, with headquarters in New York City. Before going to New York, Mr. Langan served his company in Philadelphia, Baltimore, Buffalo and as manager of the Syracuse office. He has been active also on engineering committees of the A. E. R. A., was president of its Metropolitan Section in 1928 and for the past three years has been busy as a member of the subject committee of the New York Railroad Club.

W. F. James (M'20) formerly the Middle Atlantic district manager of the Westinghouse Electric & Manufacturing Company, has been appointed assistant to the commercial vice-president of the Atlantic Division of that company. He has been a member of the Westinghouse organization since 1909. Mr. James is a past-president of the Electrical Association of Philadelphia and of the Engineers Club of Philadelphia, a member of the industrial relations committee of the Philadelphia Chamber of Commerce, and a member and past regional vice-president of the A. I. E. E.

R. J. Wensley (A'28) creator of the televox, first of popular mechanical robots, has been transferred from the East Pittsburgh engineering department of the Westinghouse Electric & Manufacturing Company to the company's meter department at its Newark works. Mr. Wensley has done notable work in connection with switchboard and automatic switch design and is a recognized authority in the field of intricate electrical control equipment. During 1929 he served on the A. I. E. E. subcommittee on automatic substations.

G. I. Wright (M'28) in charge of electrification for the Reading Company (Philadelphia) since 1927, on May 16, 1931 was made its chief electrical engineer in charge of all electrical and signal engineering. Mr. Wright, who at one time was assistant electrical engineer of the Illinois Central Railroad Company, continues as a member of the A. I. E. E. transportation committee. His new appointment is largely in recognition of the capacity he has shown in the work.

D. C. Jackson, professor of electrical engineering at Massachusetts Institute of Technology recently received the annual Lamme Medal award of the Society for the Promotion of Engineering Education, presentation being made at the annual convention at Purdue University, Lafayette, June 17, 1931. This award is made "for accomplishment in technical teaching or actual advancement of the art of technical training."

H. E. M. Kensit (M'08) after nearly twenty years in the Dominion Civil Service, retired August 1, 1931, to engage in private practise. His investigations and construction work in the United States and Canada included a detailed investigation of The South Saskatchewan Water Supply Division Project, involving comparative costs from all available power sources; water, steam, gas, and oil.

E. W. Loomis (A'19) who a few years ago was advanced from manager of the mill and mining section of Westinghouse Elec. & Mfg. Company to manager of the company's northeastern industrial division, now has become Middle Atlantic district manager with headquarters in Philadelphia, Pa.

T. C. McFarland (A'22) who for the past year has been doing special work in engineering at the Bell Telephone Laboratories, Inc., New York, now has returned to Berkeley, Calif., to resume his duties as associate professor of electrical engineering at the University of California.

R. G. Meyerand (A'28) who has been serving the Stone & Webster Engineering Company (Boston) as assistant to the chief electrical engineer, has been appointed sales engineer of the Rockbestos Products Corporation, New Haven, for its New England territory.

W. S. Richhart (M'13) manager of the light and power department of the Indiana Service Corporation, Fort Wayne, Ind., one of the Insull properties, now has assumed charge of the distribution service of all Insull properties included in the Midland United Company.

W. M. Herbruck (A'25) formerly with the engineering department of the Ohio Power Company, Canton, Ohio, now has the position of chief electrical inspector for the American Electric Switch Corporation, Minerva, Ohio, still retaining residence in Canton.

K. B. Thornton (M'13) who for a number of years, has been serving the Canadian Electric Railway Association at a recent meeting in Ottawa was elected president, the highest honor that can be conferred upon an electric railway operator in Canada.

W. S. Gifford (A'16) president of the American Telephone & Telegraph Company, New York, N. Y., was elected a member of the American Philosophical Society at its recent annual meeting held at the University of Pennsylvania, Philadelphia, Pa.

A. B. Day (M'16) president and general manager of the Los Angeles Gas & Electric Corporation recently was elected president (1931-1932) of the Pacific Coast Electrical Association, in which he has been actively interested for several years.

O. K. Marti (M'27) formerly chief engineer of the American Brown Boveri Co., Inc., Camden, N. J., is now associated with the Allis-Chalmers Mfg. Company in Milwaukee, Wis., as engineer in charge of rectifiers and railway equipment.

L. B. Andrus (F'19) president of the Indiana Electric Corporation, and a Life Member of the Institute, has been chosen by the National Electric Light Association to assume the presidency of its Great Lakes Division for 1931-1932.

W. E. Gutzwiller (A'30) until recently electrical engineer for the American Brown Boveri Co., Inc., Camden, N. J., has moved to Milwaukee, Wis., to take a position in the rectifier department of the Allis-Chalmers Mfg. Company.

A. S. Brown (A'30) instructor in the electrical engineering department of the University of Kansas, Fayetteville, Ark., until September 1 then became graduate research assistant, Kansas A. & M. College, Manhattan, Kansas.

E. H. Morris (A'23) for many years chief engineer of the Board of Railroad Commissioners, State of North Dakota, recently was appointed chief engineer of the Public Service Commission of West Virginia, Charleston.

G. T. Harness, Jr. (A'30) will serve in the capacity of assistant in E. E. at California Institute of Technology, Pasadena, on leave of absence from the College of the Pacific to work for his Ph. D. degree.

T. A. Fawell (M'20) formerly connected with the San Francisco office of the Marwood Company of California, Ltd., has been appointed manager of the Los Angeles office of that company.

R. C. Marshall, Jr. (M'19) who has been serving the Sumner Sollitt Co., Chicago, Ill., as president, is now vice-president in charge of the B-W Construction Company, also of Chicago.

R. D. Bean (A'21) who was manager of engineering development for the Brown Instrument Company, Philadelphia, is now chief engineer of that company.

President C. E. Skinner is the appointed representative of the American Standards Association on the council of the International Standards Association.

Obituary

William E. Richards (A'14-F'26) superintendent of electrical distribution for The Toledo Edison Company, Toledo, Ohio, died suddenly in his office August 12, 1931. He was born at Waynesburg, Ohio, October 20, 1863. In the early eighties he installed and operated an electric light plant for the Thompson-Houston Company at Newton, Iowa, and in 1891 returned to Ohio in responsible charge of electrical and mechanical operations for the Consolidated Street Railway Company, the various organizations of which occupied him until his death. Many of the advances of the Toledo Edison system were pioneered by him; he also planned and installed the floodlighting system in the Statue of Liberty, receiving therefore a gold medal from the City of New York.

Besides his membership in the Institute, Mr. Richards was a member and an active worker in the Toledo Chamber of Commerce, The Edison Association, the National Electric Light Association, the Illuminating Engineering Society, the Ohio Good Roads Federation, and several other local organizations, professional and social. He was at one time chairman of the Institute's Toledo Section. Endorsing his transfer to the grade of Fellow of the Institute, J. B. Taylor (F'14) consulting engineer, General Electric Company, stated in 1925 that "Mr. Richards has met and solved many special problems in the distribution of power, both d-c. and a-c., at low and high voltage. Resourcefulness and ingenuity exercised over a long term of years gives him a unique position in the central station field."

Alva C. Dinkey (A'97) former president of the Midvale and Carnegie steel companies, and a pioneer in the steel industry in Pennsylvania, died at his home August 10, 1931, after a three-months' illness. He was sixty-five years old, and a well-known figure in the great steel activities of the country, having been engaged in the steel industry since beginning work in the Edgar Thomson Steel Works at the age of thirteen. He became president of the Midvale Steel and Ordnance Company, later the Midvale Steel Company, in 1915. His interest was largely in the electrical end of the steel industry, and throughout his life he was a close friend of Charles M. Schwab. Mr. Dinkey was a member of The American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers, the Engineering Society of Western Pennsylvania, the Engineers Club of Philadelphia, the American Association for the Advancement of Science, and the Academy of Natural Sciences. He also held membership in the Racquet, Manufacturers, Sunnybrook, Five O'Clock (Philadelphia) Duquesne (Pittsburgh) clubs and the Indian House and Pennsylvania Society of New York.

George Gault Cree (A'22-M'30) of the central station engineering department General Electric Company, Schenectady, was drowned in Lake Ontario July 20, 1931. He was attending camp and had gone for a sail with a number of the company's officials, when a violent squall capsized the boat. Mr. Cree, who was not a strong swimmer, sank and exhaustive effort failed to reach him. Born in Scotland in 1888, he was educated in English and Scotch schools, and entered the General Electric Test course at Schenectady in 1919. After a number of years abroad he entered the central station engineering department where his experience and personality won the confidence of the utilities with which his work brought him in contact. He was a member of the N. E. L. A. apparatus committee, and of late had become prominent in local Boy Scout movements.

Bruce Ford (A'11) until recently general manager of the Electric Storage Battery Company, Philadelphia, of which he also was vice-president, died at his home near Philadelphia, August 10, 1931, after a brief illness. He was born in Brooklyn, N. Y. in 1873, and had been in the organization of the Electric Storage Battery Company since 1890, except for a few years in the early part of his career. More than fifty patents on inventions relating to storage batteries are registered in his name. Mr. Ford was a director of the Chloride Electrical Storage Company, Ltd., Manchester, England, and a member of the American Society of Mechanical Engineers, Franklin Institute, the Engineers Club (New York and Philadelphia), the Philadelphia Cricket Club, the Old Colony Club, and the Military Order of the Loyal Legion.

Lewis Judson Wells (A'24) sales engineer for the Diamond Electrical Manufacturing Company, Los Angeles, Calif., was killed in an airplane accident July 16, 1931. He had been with this company and its affiliated organizations since graduating from the California Institute of Technology in 1922. An interest in the art of flying led him to spend most of his leisure hours in the air.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Bunce, Lewis I., Rocky Hill, Conn.

Clark, Bernard, 79 Jenness St., East Springfield, Mass.

Cole, Will G., Box 222, Westwood, Calif.

Corriveax, F. M., General Electric Co., Schenectady, N. Y.

Deacon, L. O., 6 Ailsa Ave., East Malvern, Melbourne, Australia.

Furui, Shungo, Shibaura Engineering Works, Tokyo, Japan.

McLean, James S., 190 Old Army Road, Scarsdale, N. Y.

Melson, Sydney W., Yeatton Woolwich Road, Abbey Wood, London S. E. 2, England.

Mountain, C. E., Burma Elec. Supply Co., Mandalay, Burma, India.

Nuber, Frank J., 3831 Rokeby St., Chicago, Ill.

O'Shea, V., Jr., 115 Broadway, New York, N. Y.

Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.

Prudham, W. M., 100 Biddle St., Wilkinsburg, Pa.

Schrock, John E., 3720 Main St., Lawrence Park, Erie, Pa.

Sullivan, John E., 6320 Kenmore Ave., Chicago, Ill.

Tate, William, Apartado No. 41, Puebla, Mexico.

Tung, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Letters to the Editor

Has Man Benefited by Engineering Progress?

Apparently the first article of The Engineering Foundation's symposium, concerning the possible benefits accruing to and through mankind as a result of engineering progress, as published in the August issue of ELECTRICAL ENGINEERING (C. E. K. Mees, p. 642) has appealed to different people in different ways. Among the letters received by the editors are the following:

To the Editor:

Doctor Mees's article, "Has Man Benefited By Engineering Progress?" in the August issue, is a refreshing contrast to the average engineer's blind worship of mechanical progress. It is as pleasant as it is unusual to find an eminent technician free from the common error of identifying industrial with human progress.

If in accordance with Doctor Mees's definition, engineering is taken as embracing all of applied science, its development, particularly in the field of medicine, has certainly been of notable benefit to mankind. The gain is small, however, in comparison with the benefits which would result if progress in the subjective elements of civilization kept pace with technological advancement. That it has not done so is of course a truism. Moreover, the inability of men to cast off superstition in their emotional and social life as fast as they discard it in dealing with the mechanics of existence is fraught with the gravest menace. Machinery merely amplifies the capacity for evil of the stupid and sadistic herd and its leaders. "Against stupidity," said Schiller, "the gods themselves fight in vain." Give to stupidity or ferocity modern machine guns and automobiles, and the gods might as well retire from the conflict altogether. It looks at times as if they have already done so.

For all this the engineers are as much to blame as educators, priests and magistrates. The very success of the engineering profession places on it some measure of responsibility for the misuse of its implements. The engineer is both too proud and too humble. He is too proud, because, unlike Doctor Mees, he seldom apprehends the narrowness of his contribution. Because of the feeling of power he derives from it personally, he comes to regard it as an end in itself. He is too humble, because he will not even raise his voice in protest against the perversion of his creations. He is like a designer of firearms who having created a particularly neat and powerful engine of destruction, puts it into the hands of a chimpanzee and goes on his way rejoicing.

The stability of society is at least as important as the stability of an electrical distribution system; but as long as this attitude is general, there is no hope of curing the fundamental evils of communal life. On the contrary, blind industrial proliferation will merely increase our hazards and the extent of our failure. Both the lowly and those high in power are uneasily conscious of the inability of mankind to adapt itself to the complications of the Machine Age. The principal burden of shame is on the successful and the competent. It matters little to the individual whether he starves because there is not enough food in the world, or too much. But the latter condition is much more disgraceful to society than the former.

There is perhaps nothing that the engineer, as a highly specialized helot of business, can do in an immediately practical sense, but it is encouraging to see him begin to think along the lines of the forthcoming series of papers. He may learn that the proper study of mankind is man, and not merely transmission lines, circuit breakers, and car couplings. He may be forced to acknowledge that, at the present stage, psychiatry and the social sciences are more important than further progress in engineering, and if he is somewhat humbled in his own estimate of himself, it may increase his usefulness in the long run.

Sincerely yours,
CARL DREHER (A'23)
(Director, Sound Dept., R. K. O
Studios Inc., Los Angeles)

To the Editor:

You have asked for comments on the article, "Has Man Benefited By Engineering Progress?" by Dr. C. E. Kennedy Mees. It would require a rather extended discussion to refute Doctor Mees's beliefs. It is undoubtedly true that one's judgment on the influence of engineering progress on human welfare will depend upon the definition or assumption of the meaning of the term benefited. It seems to me that Doctor Mees has given an exceptional narrow meaning to this term. I believe the term human welfare, as used in the preamble of the Constitution of the United States, comes nearer expressing living conditions that have been influenced by engineering progress.

If we consider the contributions of engineering progress toward the fulfillment of the aims specified in the preamble of the Constitution, there is no doubt in my mind but what engineering progress has done more to promote the general welfare and to secure the blessings of liberty to ourselves and our posterity than all the philosophies written since Aristotle.

Doctor Mees asks the question, "will any student of history agree that the inhabitants of an American city are any happier on the whole than those of the Greek or Babylonian cities of the past?" The degree of happiness is incommensurable. If we substitute for happiness, welfare, I have no hesitancy in stating emphatically that the inhabitants of an American city have on the whole a much higher state of well being than the majority of the inhabitants of the Greek or Babylonian cities. It is useless to deny that the Greeks developed a high state of culture, but that culture was merely a crust superposed upon a state of society which today would not be tolerated even in a semi-civilized community. In so far as advancing the civilization—that is, improving the social conditions of the masses—of its own period is concerned, the philosophies of Greece and Rome did no more than the pyramids of Egypt or the palaces of Peru. Human progress was not arrested because ancient civilizations fell, but the civilizations fell because human progress had been arrested.

Doctor Mees still has the privilege of walking a short distance. At the same time he can ride a long distance if occasion demands, and on the way he may acquire by such experience an appreciation of life in remote regions. All of life and culture is not confined to a garden. The emotions aroused by the majesties of the Grand Canyon and of the snow-capped mountains are just as cultural as those aroused by a poem, a book on philosophy, or a growing radish. They are, however, beyond the confines of a garden and beyond the limits of short walk. Likewise, Doctor Mees still has the privilege of attending to his business in a leisurely manner, to live in a small city, to cultivate a small garden, but I see that he lives in Rochester, New York. Assuredly, then, the attractions of a large city are more alluring and satisfying than living in a small city.

Very truly yours,
C. M. JANSKY (A'06)
(Professor of Electrical Engineering, University of Wisconsin, Madison)

To the Editor:

A few comments on the article, "Has Man Benefited By Engineering Progress?" by Doctor Mees.

Perhaps it would be well to think of the advancement of modern life as a series of tedious climbs from one level to another with resting places along the way.

It is apparent that mankind has been advancing rapidly and fighting feverishly to maintain a higher level of living for the past decade. Without the equipment of life sufficiently perfected to hold the level, so that the accomplishment has been made with a sacrifice of human happiness.

It is quite apparent that the equipment necessary to the security of such a level has been satisfactorially perfected at this time; and that the plane of life can now be maintained, through its application.

The necessities of life can be abundantly supplied with the available equipment and with a very effective decrease in man hours that will occur when economic conditions are fully understood.

There is little to fear in the form of revolution, though at this time, such a turn might seem inevitable.

This new level of life with its new standards of living was arrived at rapidly and we do not yet know how to curtail its productivity without injuring human happiness. Though we know man hours must be decreased materially.

The solution slowly evolves as Engineering applies the Science of Economics.

Yours very truly,
ORRIN S. VOGEL (A'29)
(Electrical Engineer, Georgia Power Company, Atlanta)

To the Editor:

Dr. Mees, in the August issue of ELECTRICAL ENGINEERING, takes a very pessimistic view of engineering's contribution to human progress, and I should like to present a point of view that will lend a little more rosy tint to the accomplishments of science and its handmaiden, engineering. We all realize that points of view are many and are usually taken by choice according to the temperament of the chooser. It must be confessed that between two views equally rational and consistent with the facts of history I should choose the more optimistic.

The yardstick by which I should measure the progress of the world is *consciousness*. Of course there are many definitions of the term and much will depend upon which definition is chosen. The sense in which I wish to use it, is the very broad one which includes both intellectual and emotional knowledge. For a further interpretation of this concept we might give as one reference the books of Prof. Warner Fite. To increase consciousness seems fully as fundamental an aim or purpose of mankind as any mentioned by Dr. Mees, even in its narrowest sense.

Life from the very beginning can be interpreted and explained in terms of such a measure very remarkably. The discoveries of speech and writing are the very foundations of the human race as we know it, and it is reasonable to suppose that progress in the future will be the result of other such remarkable discoveries. A return to the state of the contented cow can be justified on many grounds, but not on the ground of increasing consciousness. Is it not proper to value the forces that have made us and look for their continuance in estimating progress?

Let us for a moment attempt to evaluate science in terms of increasing consciousness. Many of the results of science sink away into nothingness; for example, those things which create mere comfort and draw people from, rather than to, an active life. The great achievements, not always without pain and discomfort to many, appear as those that have added to better communication, recording, and understanding. Photography, wireless telephony, talking pictures, better transportation, cheaper books and magazines, and, in the realm of pure science, the new understanding of the universe and of the need for higher dimensions. These are the things that are going to lead to a race as much higher than we, as we are higher than the cave man.

It is true that engineering has been concerned almost entirely with material things, and in so far as it is limited to them it is insufficient; however, no one but an engineer will say that engineering is the whole of life. Owing to the spread of an artificial scientific attitude, religious fervor and spiritual awakening may even have suffered temporary setbacks, but how much greater will they be when man turns the instruments he is as yet just beginning to discover in the direction of things immaterial; immaterial yes, but more lasting and more powerful in human good than anything now imagined.

Yours very sincerely,
W. C. JOHNSON, JR. (A'29)
(Electrical Engineer, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.)

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ELECTRICAL ENGINEER, 1930 graduate, 25, single. Eight months' construction experience; one summer with public utility, one year G. E. Test including six months on vacuum tubes. Eastern location preferred. Interested in any position except sales. Available on short notice. C-9591.

ELECTRICAL ENGINEER, 36, married, 18 years' experience on power plants, transmission lines, substations, switchboards, telephones, mine electrical equipment, motors, lighting, marine electrical work, draftsman. Five years' electrical engineer wiring for power, light, telephones, signal systems, elevators for all types of buildings. Also expert plumber, heater and tinner. C-9348.

1931 ELECTRICAL ENGINEERING GRADUATE, age 25. B. S. E. E. in well-known engineering college. Desires work in any of th following or similar classes: industrial control, research, radio, test, design, development or maintenance. Worked through school by alternating years at school with years at work. Excellent references. Industrial experience. Honor student. C-9518.

MANAGER, SUPERINTENDENT, RESIDENT OR OPERATING AND MAINTENANCE ENGINEER, technical graduate, B. S. in E. E., 22 years' experience, engineering, construction, operation and maintenance of steam; hydro and Diesel power stations, transmission and distribution systems, as well as special process and heavy mechanical equipment and industrial plants. C-9597.

ERECTING ENGINEER, 46, of broad experience in power plant construction, maintenance, and operation. Exceptional ability in the erection and wiring of switchboards, power plant auxiliaries, oil circuit breakers, and high-voltage outdoor substations. Available immediately. C-8792.

ELECTRICAL ENGINEER, 32, married, 8 years in iron and steel works, oil fields, etc.; electrical installation and maintenance. Three years central and substation electrical plant installation. Five years electrical drafting of rolling mill, coal mines, and public utility electrical plant. Anywhere United States or abroad. C-625.

1931 ELECTRICAL GRADUATE, midwest university, 22, single. Tau Beta Pi student. Desires connection with manufacturing or public utility concern. Location preferred, Middle west. C-9398.

ELECTRICAL CONDENSER ENGINEER with thorough knowledge and extensive experience in the design and application of impregnated paper, mica, and air dielectric condensers. Would like to organize or reorganize condenser department for reliable manufacturing company. Will present convincing details on receipt of correspondence. C-7970.

ELECTRICAL ENGINEER, specializing for the past four years in research and development work on hot-cathode neon arc lamps a-c. and d-c., low-voltage neon sign tubes, photo cells, mercury-rare gas, ultra-violet tubes. Desires to connect with company developing rare-gas arcs for television projection. C-9598.

GENERAL ENGINEER, primarily electrical, 37, countrywide experience with largest engineering and construction corporations. Responsible charge utility and industrial design, application, study, report, appraisal, operation and superintendence of construction. Successful contacting clients and handling men. Experienced in mechanical and structural practises. Now employed. Interview at Boston or New York. C-9627.

GRADUATE ELECTRICAL ENGINEER for shop supervision, research or development. Six years' shop, assembly and test. Twelve years design high-voltage out-door equipment. Knows shop tools by actually serving in shop. Has inventive ability, pleasing personality, and knows men. Age 40, married, now in Middle-West. C-9641.

ELECTRICAL ENGINEER, 24, single. Degree B. S. in E. E., Marquette '31. Three and one-half years' cooperative work in large manufacturing plant. Four years' housewiring experience. Location, Middle West, preferably Milwaukee. C-9642.

ELECTRICAL ENGINEER (Cornell), well known in South Africa for many years, and having an established engineering business in Johannesburg, seeks agencies for American electrical apparatus and supplies suitable for mining and industrial uses. C-9657.

ELECTRICAL, RADIO ENGINEER, 31, graduate with B. S. E. E. University of California. Experience in electrical and mechanical design, test and operation of radio and high-frequency circuits, apparatus. Experience in design and development of heavy power automatic switchboards and gang switches. Excellent references. Location preferred, New York. Available at once. C-6734.

ELECTRICAL ENGINEER, graduate of Lehigh University, 1930, age 25, one year on general test crew of large Pennsylvania Utility company. Mechanical and electrical experience. Three months for telephone company as student engineer. Can come for interview promptly. All references desired. C-9659.

ELECTRICAL ENGINEER with years of sales experience in the Middle West desires connection with headquarters preferably in Cleveland. University graduate in E. E. knows selling and advertising of technical products thoroughly. Would be excellent representative for growing manufacturer or publisher. B-8614.

MANAGER, electric light properties, 39, Protestant, married, 15 years' experience, sales, public relations, line-building, operation, maintenance, costs, franchise work, meters, transformers, accounting, billing, collections. District manager for property having 75 employees; sold out own property in Minnesota. Desires similar or departmental position anywhere; preference Middle West. Available immediately. Salary secondary to opportunity. C-9670.

COMMUNICATION ENGINEER, 31, single. Experienced telephone, radio installation; design, development of testing equipment for telephone, radio, sound-picture circuits; design, use of semi-, full-automatic testing circuits to eliminate human element in testing; industrial applications of photoelectric cells, thermionic tubes. Best references as to professional ability, personal integrity. Location, immaterial. Available immediately. C-9376.

ELECTRICAL ENGINEER, graduate eastern university, 1930 member honorary society, Iota Alpha. Ten months' experience Westinghouse Test on distribution and instrument transformers commercial tests and phase-angle measurements. Also in testing department, large public utility for a summer on engineering tests. Desires position in engineering field with opportunity. Location, immaterial. C-9564.

CENTRAL-STATION DESIGN ENGINEER, 33, graduate M. I. T., eight years' experience covering complete engineering design of generating stations, high-voltage switching stations, substations and transmission lines; including estimates, specifications, and purchase of equipment. Experience includes 18 months on the G. E. Test course and one year in th field. Married. C-4338.

ELECTRICAL DESIGNING ENGINEER, 25 years' experience with public utilities and industrial companies, power house and substations, steam and hydroelectric, copper ore and nitrate ore reduction plants, married. Seeks permanent connection, responsible position, anywhere in United States and Canada. New York State P. E. license. B-7031.

ELECTRICAL ENGINEER, 28 married, 1924 graduate of recognized technical college with degree of E. E. Three years' experience with large metropolitan public utility in charge of relays and system protection. Three years' experience in electrical laboratory investigating and testing all types of electrical devices. Location preferred, New York City or vicinity. B-8793.

EXECUTIVE ENGINEER (M. I. T. electrical post graduate degree). Fifteen years' experience with metropolitan power companies, large electrical manufacturer and in aeronautic test, design, research and construction. Extensive knowledge. Good leader with initiative. Will travel. B-1041.

ERECTING ENGINEER, 46 broad experience in power-plant construction, maintenance and operation. Exceptional ability in the erection and wiring of switchboards, power plant auxiliaries, oil circuit breakers, and high-voltage outdoor substations. Availabl immediately. C-8792.

ENGINEER, age 27, B. S., three years and seven months C. E. experience. Desires position with hydroelectric project. Qualified for chief of party, transitman, estimator, assistant engineer. C-9382.

ELECTRICAL ENGINEER, over 17 years' experience in light and power field, several years in charge of work, desires position in charge of electrical engineering work for central station company, either with or without construction and operating duties. University graduate, good technical knowledge, and ability to handle men. B-1923.

1928 GRADUATE ELECTRICAL ENGINEER, age 24, General Electric Company over two years, including one year test on power and control apparatus and one year laboratory development and measurement. Desires position with industrial company or with scientific school. Prefers Philadelphia or New York. C-9683.

SENIOR ELECTRICAL ENGINEER, 35, married. Considerable experience in projection and complete design of mills, power plants, distribution and other industrial phases. Some development experience. Urgently in need of placement. B-3172.

RAILROAD ELECTRICAL ENGINEER, six years varied design, construction, operating experience large western and eastern railroad electrifications; familiar with American, European practise regarding transmission lines, substations, catenary systems, motive power. American, college graduate, good references. A. I. E. E., A. S. M. E., A. R. A., AEREA. membership. C-8463.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E., 1931. Single, 25. Courses taken include design, radio, and telephone.

Slight knowledge of Spanish and German. One year's experience with electrical prospecting company. Desires position with any manufacturing or engineering concern. Location and salary secondary, opportunity and experience being main factors. C-9692.

1931 GRADUATE ELECTRICAL ENGINEER, age 22, married. B. S. in E. E. from Pennsylvania State College. Three months' experience as assistant engineer with telephone company and two months in system operating department of large power company. Desires position with utility, engineering, or manufacturing concern. Location, immaterial. References. Available immediately. C-9695.

VALUATION ENGINEER, graduate of technical school of standing with B. S. E. E. degree, 29, married. Over five years' experience in appraisal and financial work for public utilities. Desires position with consulting engineer or with banking or investment company dealing in utility securities. Present unemployment due to a merger. Available immediately. C-9700.

ELECTRICAL ENGINEER, B. S. degree 1929, single, 23; desires engineering or sales work with opportunity for advancement. Has year and a half experience in service department of power company. Location, immaterial. References. Available immediately. C-9034.

ELEVATOR ENGINEER, 37, married, E. E. degrees at Cornell, '20. Six and one-half years' practical experience in the engineering, manufacture and production of elevators; three additional years in application of control and signal equipment to elevators. Desires sales or sales engineering work. Location, Midwest preferred. C-4486.

1931 TECHNICAL GRADUATE of eastern college, B. S. in E. E. Experience in Bell telephone laboratories, Western Electric Company and Perryman Vacuum Tube Company. Familiar with power-line carrier telephony, vitaphone presentation, vacuum-tube production and research. Honor student at college. Desires position with a well-organized firm. C-9661.

ENGINEER, for the past 20 years in responsible positions in connection with design and construction of electric power plants, switching stations and transmission lines; also reports on electric utilities, with antecedents as blast-furnace, rolling-mill and waterworks engineer, seeks responsible work requiring preferably a combination electrical, mechanical and structural engineer. C-9332.

ESTIMATING ENGINEERING, B. S. degree in E. E., age 34, married. Ten years' experience with large company manufacturing electrical power equipment, includes designing electrical and mechanical construction and calculating cost, weight, and dimensions of this apparatus in connection with customers' negotiations. Available at once. Location, immaterial. C-4633.

ELECTRICAL ENGINEER, B. S. degree Lehigh University, single, age 22. Desires position with utility, construction, or manufacturing company. Location, immaterial. One summer with New York Edison Company, Test Bureau. Available immediately. C-9702.

ELECTRICAL ENGINEER, B. S. in E. E., University of Michigan, August 1931. Eight months student engineer with electrical manufacturer prior to graduation. Associate member of Sigma Xi. Full member of Sigma Rho Tau honorary speech society. Unusual success in collegiate debating and public speaking indicate desirability of sales work. Location, immaterial. C-9709.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E., 1931, intends to study for M. S. degree at night; 21, single. Desires position in any electrical engineering field including radio or vacuum-tube work. Available at once. Location, New York preferred but not essential. C-9467.

ELECTRICAL ENGINEER, 26, single, Swiss graduate, 1928. Full quota immigrant. Experience: assistant designer of transformer stations and substations. Insulator testing. Research in the States. Graduate student at M. I. T. Speaks fluently French, English, and German. Connection with outstanding firm; testing, research, or manufacturing desired. Location, immaterial. C-9654.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E., 1928, 26, single. Two and one-half years' experience as designing engineer on distribution and metering transformers. Desires position with public utility, contracting, or industrial concern. Available at once. Location, immaterial. C-9693.

ELECTRICAL ENGINEER, two years' Westinghouse Test; 25 years' experience, partly in South America as engineer and manager of public utilities, and mining. Speak Spanish fluently. Also Diesel-engine and refrigeration experience. Location, immaterial. B-5912.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with eight years' experience in industrial plant construction and maintenance; railway electrification; power-plant design, estimating, and construction. Supervisory experience on construction and costs with contractor. Desires position with utility manufacturer or contractor, where ability to handle labor and produce results is a prerequisite. C-4428.

1931 ELECTRICAL ENGINEERING GRADUATE, age 23, B. S. at North Carolina State College. Desires position with opportunity for advancement with utility, manufacturing, or any other engineering firm. Can furnish best of references. Location preferred, East or Middle West. C-9660.

ELECTRICAL ENGINEER, B. S. in E. E. '31, 23, single. Has had some experience in telephony. Desires position with power or telephone company. Available immediately. Location, immaterial. C-9710.

1931 TECHNICAL GRADUATE, B. Sc. in E. E. from a midwestern university, desires permanent connection with chance for advancement. Age 26. Location, immaterial. Available immediately. C-9717.

SALES ENGINEER, graduate E. E. and N. Y. State licensed professional engineer, twelve years' experience, capable correspondent, thoroughly familiar with routine office details, sales-promotion programs, training and handling men, direct sales to industrials and utilities, preparing specifications, designing industrial motor drives, control wiring diagrams and substation design. C-5239.

JUNIOR ENGINEER, 1931 graduate, B. S. E. E., University of Alabama. Desires position with utility, construction, manufacturing company. Location, immaterial. Experienced in power-plant and building installation and industrial control, having been employed for eight summer months and one full year, first as electrician helper and later as first-class electrician. C-9446.

GRADUATE ENGINEER, B. S. in E. E., 25 years' experience in electrical, mechanical design operation, maintenance and construction of power plants. Last seven years on construction and putting in operation of power-plant equipment. Combustion, heating and high-pressure piping installations. Available now. C-7848.

SALES ENGINEER AND EXECUTIVE, electrical and mechanical training, seven years' sales engineering and executive experience in application of precision equipment to electrical equipment. Would like opportunity to develop sales of mechanical product allied with electrical industry or of electrical nature sold to central stations and industrials. C-5431.

1930 ELECTRICAL ENGINEER, Rensselaer Polytechnic Institute, 24, 5'8¾", 160 lb., in very good health, desires immediate connection. Will go anywhere, anytime; will take foreign service if necessary. Hydroelectric and power maintenance, construction and installation before graduation. Willing to start in as draftsman if necessary. Quite studious and ambitious. C-7936.

ELECTRICAL ENGINEER, technical graduate, 32, married. Twelve years' experience in design of steam and hydroelectric power stations, bus-stations, and industrial plants, including estimates, costs, specifications, purchase of equipment, drafting, and construction supervision. Desires position with public utility, engineering or industrial concern. References. New England preferred but will consider other location. C-9715.

ELECTRICAL ENGINEER with wide practical experience in design, construction, operation, distribution, superintendence of gas and electric public utilities, desires permanent connection with industrial organization in the Middle or Far West. C-9668.

RECENT GRADUATE, 23, Pratt Institute in industrial electrical engineering. Desires position with power company or related work in manufacturing or construction. Location, East. C-9727.

MECHANICAL AND ELECTRICAL ENGINEER, research, development, reports. Phys. tests of material. Metallography, X-ray analysis. Languages: French, and German. Available on short notice. Location, immaterial. C-6994.

ELECTRICAL ENGINEER, graduate Lehigh University 1922. Experienced all kinds construction, transmission work power plants, substations, etc. mostly as draftsman laying out such work. Also familiar with electrification in anthracite fields. Willing to accept drafting, engineering, or any other electrical position. Location, eastern states preferable but anywhere considered. C-9723.

GRADUATE ELECTRICAL ENGINEER, 22, single, B. S. in E. E. 1931, Lehigh University. Three months' summer experience testing department large public utility. Desires position with utility company. C-9721.

INTERNATIONAL OR DOMESTIC BUSINESS, university graduate, 31, thoroughly trained and experienced, seven years engineering and business U. S. and abroad; export, power system planning, developments, reports, estimating, organizing; foreign languages: German, Spanish, some French. Desires connection holding company or trade; will consider representing concern abroad. Available short notice. C-3534.

INTERNATIONAL BUSINESS, electrical engineer, 30, single; citizen, college graduate here and abroad, widely traveled, speaks Scandinavian, German, fair French, some Russian, five years' American engineering experience, power plant and substation design and construction. Desires permanent position with holding company or representating manufacturer abroad. Excellent references. Personal interview desired. Location immaterial. C-9730.

ELECTRICAL ENGINEER, 43, married; twenty years' electrical, power, and industrial plants experience in construction, maintenance of distribution and transmission lines; desires position with public utility or industrial plant. Can qualify as electrical superintendent. Used to handling men. Available short notice. Canada preferred but would consider other location. C-9459.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
A. K. Krauser, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

ELECTRICAL - MECHANICAL ENGINEER, 24, single, graduate Cooper Union night school of engineering, 1931, degree B. S. in E. E. Eight years' industrial experience including machine shop, mechanical, electrical design work; some radio and patent work. Speak German fluently. Desires position, vicinity of New York City or suburbs. Available immediately. Excellent references. C-8357.

ELECTRICAL ENGINEER, B. S. in E. E. from well-known institution, 1931, single, 22, available immediately. Summer experience in generator design, sales, and shop work. Research experience in industrial power tubes. Excellent scholastic record. References furnished. Moral habits and good health. Location, immaterial. C-9699.

ELECTRICAL - MECHANICAL ENGINEER, 44, married, technical university graduate. Eighteen years' practical experience; design, test, operation of a-c. and d-c. motors, generators, contactors, relays, switches, controllers, electro-mechanical devices. Elevator and hoisting equipment, construction and installation. Technical management. Development and production work. Location, New York City vicinity or East. Available immediately. B-5240.

ELECTRICAL - MECHANICAL ENGINEER, married, graduate electrical engineer, New York and New Jersey professional licenses, 15 years' experience illumination, flood-lighting, wiring, service vaults, house switchboards, and underfloor duct for office buildings. Maintenance and plant engineering work in textile, zinc, steel, and small parts manufacturing plants. Specifications, purchasing and executive experience. B-5026.

ASSOCIATE ELECTRICAL ENGINEER, 37, married, twelve years with Westinghouse; apprentice course, sales and shop. One and one-half years Western Electrical Engineering department, writing inspection methods instructions. Knowledge of oscillograph testing and meters. C-8817.

MANAGER, EXECUTIVE ENGINEER, 41, superintendent, consultant, sales engineer, assistant to major executive. Electrical utility properties, management organizations, industrials, manufacturers. Broadly trained, twenty years diversified responsibilities, five connections. Demonstrated ability large projects. Sound economical design, construction, operation. Extensive changeover programs, networks, underground systems. Vitally energetic, American. Salary not immediate objective. C-3963.

ELECTRICAL ENGINEER, experienced also in metallurgy and electro chemistry, has been employed for more than six years in physical research laboratories, desires similar position. B-9034.

1931 GRADUATE ELECTRICAL ENGINEERING, B. S. in E. E. University of Delaware, single, age 21. Special courses taken in physics and radio. Desires position with any manufacturing or engineering firm. Location, immaterial, opportunity and experience being main factors. Available immediately. C-9666.

ELECTRICAL ENGINEERING ASSISTANT, 26, married, college graduate, four years' transmission and distribution experience with public utilities on design, estimates, survey, and evaluation. Desires connection with public utility engineering department. New York City preferred, but will consider any United States location. C-5511.

1930 GRADUATE OF ELECTRICAL ENGINEERING, under the cooperative plan at Georgia Tech. Worked alternate months with public utility company in Georgia in the following departments: car-barn, gas, engineering, hydro-generation, and statistics. Since graduation has worked six months with transmission line construction crew. Any location. C-9210.

Instructors

ELECTRICAL ENGINEER, 36, desires position as professor or instructor in E. E. at college, university or technical school. University graduate; two and one-half years' instructor; two years' machine design with Westinghouse; seven years' design of electric power stations; competent supervisor. Correspondence invited. C-9593.

INSTRUCTOR in design engineering. Ten years' practical experience on the design, construction, installation and calculations of overhead distribution lines and underground networks. Location preferred, Southwest. Available at once. C-4784.

ELECTRICAL ENGINEER, B. S. E. E. '29, M. S. E. E. '31, leading university, eighteen months General Electric Test, 23, single. Desires to teach in technical university. Prefers Midwest. C-9320.

GRADUATE ELECTRICAL ENGINEER, M. S. in E. E., 1931 from M. I. T. General Electric Test experience. Experience in the design of motors and generators. Available upon short notice. Location, immaterial. C-9559.

ELECTRICAL ENGINEER, B. S. E. E. degree from southern university, 1930, age 21, single. Desires position with manufacturing concern offering a future, or as instructor in electrical engineering. Location, immaterial. Available at once. C-9607.

ELECTRICAL ENGINEER, college graduate, advance studies, 29, married, Westinghouse training. Six years' experience as designer of electrical circuits and mechanical details of control apparatus. All kinds of control apparatus, specializing on elevators. Qualified for responsible position. Location, immaterial. Available on short notice. C-9638.

ELECTRICAL ENGINEER, teacher, married, university graduate. Four years instructor in state university; five years in testing and design departments of operating company; six years with consulting engineering firm in central station design; eight years with engineering and management corporation, five years as assistant electrical engineer. Available on short notice. C-9629.

METER OR TESTING ENGINEER, 29, B. S. in E. E., honors, standard university. Ten years' experience; utilities, standardization, meter, transmission, plant departments. Started reading meters. One year sales engineer, large instrument manufacturer. Good records and references. Qualified for industrial or utility construction, testing, or operation. Location immaterial. Will travel. Available immediately. C-9667.

ASSISTANT PROFESSOR OR INSTRUCTOR, Cornell graduate, diversified practical work, two and one-half years' teaching experience. Thoroughly familiar with present day practise in mechanical and electrical equipment for industrial and power work. A-3702.

ELECTRICAL ENGINEER, M. S. 1931 from M. I. T., 23, single. Summer xperience with American Tel. and Tel. Company. Desires position with electrical company preferably in research laboratory or as instructor in E. E mathematics, or physics. Available immediately. Location, East or Middle West. C-9674.

POSITION AS INSTRUCTOR OR ASSISTANT PROFESSOR in technical school for E. E. wanted. Age 28, degrees of S. B. S. M. in electrical engineering. Can handl classes in any phase of work relating to power plants, substations, radio distribution, or transmission. East preferred. Employed at present. C-5744.

GRADUATE ELECTRICAL ENGINEER, class 1926, Columbia, age 28, married. Practical experience with power company and telephone company. One year as laboratory assistant in electrical classes and three years as instructor in evening classes in college mathematics have aroused a sincere desire to make teaching life work, as instructor in E. E. mathematics, or physics. C-9308.

RELAY, CONTROL ENGINEER, 30, McGill graduate. Have done responsible engineering work planning relay applications, protective circuits, automatic, supervisory controls. Thoroughly familiar, equipment large generating, substations, use of laboratory facilities, field engineering methods. Valuabl experience, communication circuits, amplifiers, photoelectric cells, maintenance of highest standards in their circuits. Proved ability in personal contact. Location, Canada. C-4668.

1929 ELECTRICAL DESIGN ENGINEER, 24, B. S. degree technical school. One year Westinghouse student course. Motor, transformer, turbo test experience. One year large synchronous motor design. Six months Westinghouse electrical design school. Desires position; design, research, development work, manufacturing company, or engineering department power company. Single with dependents. Location, immaterial. References. Available immediately. C-9410.

Membership

Recommended for Transfer

The board of examiners, at its meeting of July 29, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

BURKHOLDER, CHARLES I., vice-pres., Duke Power Co., Charlotte, N. C.

CREIM, BENJAMIN W., chief elec. engr., Modesto Irrigation District, Modesto, Calif.

To Grade of Member

ALLEN, CLAYTON M., junior elec. eng., Dept. of Water and Power, Los Angeles, Calif.

BEAR, FRED T., elec. engr., Delaware Pr. & Light Co., Wilmington, Del.

BRAUN, ELMER H., junior engr., N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.

BUCK, O. KENDALL, supervising power salesman, Dept. of Water and Power, Los Angeles, Calif.

CRANE, CARL C., substation engr., Northern Indiana Public Service Co., Hammond, Indiana.

DAVIS, ARTHUR L., asst. gen'l. supt., Western Massachusetts Companies, Turners Falls, Mass.

DORMER, WILLIAM J. S., division toll-plant engr., Bell Telephone Co. of Canada, Montreal, Can.

DUNCAN, JAMES A., research engr., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

EITMAN, JOSEPH F., design engr., General Electric Co., Fort Wayne, Indiana.

HARRIS, HIRAM D., instructor in E. E. and physics, Rensselaer Polytechnic Institute, Troy, N. Y.

HOLLADAY, WM. L., engg. mgr., The George Belsey Co. Ltd., Los Angeles, Calif.

KATZMAN, JACOB, elec. engr., Dubilier Clock Corp., New York.

LEE, Jr., STEWART, engg. dept., N. Y. Shipbuilding Co., Camden, N. J.

MOORE, LEONARD J., exec. engr., San Joaquin Lt. and Pr. Corp., Fresno, Calif.

MORGAN, THEODORE H., asst. prof. of E. E., Stanford University, Stanford University, Calif.

MOSER, FRED L., supt. of maintenance, Duke Power Co., Charlotte, N. C.

NAEF, OTTO, consulting engr., American Brown Boveri Co. Inc., Camden, N. J.

POLKINGHORN, FRANK ALLEN, member of tech. staff, Bell Telephone Laboratories Inc., New York.

RICHARDSON, HARVEY R., laboratory engr., Brooklyn Edison Co. Inc., Brooklyn, N. Y.

SCHULZE, RAYMOND C. R., assistant engr., Public Service Elec. & Gas Co., Newark, N. J.

SHADGETT, LAURENCE M., supt. wholesale operations, Georgia Power Co., Atlanta, Ga.

SHARP, HUBERT, transmission engr., Mountain States Tel. & Tel. Co., Denver, Colo.

SMITH, HUGH L., engr., General Electric Co., New York.

TUCKER, WILMER H., elec. engr., The Hoover Co., North Canton, Ohio.

WALSH, HOWARD A., field engr., Doble Engineering Co., Boston, Mass.

WOODS, JOHN C., designer, Commonwealth Edison Co., Chicago, Ill.

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before September 30, 1931.

Bantau, J. W., Paramount Publix Corp., Los Angeles, Calif.

Benson, A., Oklahoma A. & M. College, Stillwater, Okla.

Coleman, G. G., The Chesapeake & Potomac Tel. Co., Washington, D. C.

Cook, J. F., Jr., R. C. A. Victor Co., Jamaica Plain, Mass.

Cruickshank, J. P., Appalachian Electric Power Co., Huntington, W. Va.

Fricker, W. R., Canadian Westinghouse Co., Ltd., Regina, Sask., Can.

Hipp, R., Jr., Broad River Power Co., Pomaria, So. Car.

Inkster, O., Saskatchewan Power Commission, Regina, Sask., Canada

Ireland, G. (Member) American Tel & Tel. Co., New York, N. Y.

Jastram, R., Star Electric Motor Co., Newark, N. J.

Kurdy, S. M., Automobile Laundry Engineering Corp., Newark, N. J.

Levoy, L. G., Jr., General Electric Co., Schenectady, N. Y.

Lytle, C. M., Kansas City Pr. & Lt. Co., Kansas City, Mo.

Maessen, F. T., 412 City-Central Bldg., San Antonio, Tex.

Merrill, C. B., Bell Tel. Co. of Pa., Pittsburgh, Pa.

Moscato, F., Automatic Musical Inst. Co. of Grand Rapids, Mich., Central Park, L. I., New York.

Murphy, P. J., Dept. of Public Works, Essondale, B. C., Can.

Porter, F. C., United Elec. Lt. & Pr. Co., New York, N. Y.

Rees, J. B. (Member) American Tel. & Tel. Co., New York, N. Y.

Roberts, W. N., Box 15, Woodside, L. I., N. Y.

Rosenberger, G. L., Virginia Public Service Co., Alexandria, Virginia

Sanford, R. V. (Member) Tucson Gas, Elec. Lt. & Pr. Co., Tucson, Ariz.

Sharp, R. E. B., (Member), J. P. Morris & De La Vergne, Inc., Philadelphia, Pa.

Stoll, G. M., N. J. Bell Telephone Co., Asbury Park, N. J.

Thorne, E. C., Southern Canada Power Co., Drummondville, Que., Can.

Tingley, F. T. (Member) Clemson College, Clemson College, So. Carolina.

Valverde, R., Valverde Laboratory, New York, N. Y.

von Turffs, H., Montana Power Co., Bozeman, Mont.

Winkler, S. C. (Member) Los Angeles Junior College, Los Angeles, Calif.

Wright, R. B., United Electric Lt. & Pr. Co., New York, N. Y.

Wyman, A. W., Warren Telechron Co., Ashland, Mass.

31 Domestic

Foreign

Gillott, J. K. (Member) Metropolitan-Vickers Elec. Co., Trafford Park, Manchester, England

Stratton, T. P., DeBeers Cons. Mines, Ltd., Kimberley, S. Africa

Ratnam, G. M., Chola Power House, Dist. Thana, Bombay, India

Thomson, L. P., Estacion Lacroze, Buenos Aires, S. A.

4 Foreign

September 1931

Order Form for Pamphlet Copies of A. I. E. E. Papers*

All papers presented at the 1931 Pacific Coast Convention

Number	Author	Title
☐ 31-122	C. C. Campbell and H. N. Kalb	Radio Coordination
☐ 31-123	C. E. Magnusson	The Kindling of Electric Sparkover
☐ 31-124	H. H. Skilling	Tuned Power Lines
☐ 31-125	E. M. Calderwood and D. F. Smith	The San Francisco-Los Angeles Section of The Pacific Coast Telephone Cable Networks
☐ 31-126	G. D. Floyd and J. R. Dunbar	Calorimeter Measurement of Stray-Load Losses of 55,000-Kva. Generator Having Enclosed System of Ventilation
☐ 31-127	T. E. Purcell and C. A. Powel	Tie-Line Control of Interconnected Networks
☐ 31-128	H. C. Hill and J. B. Se Legue	Electrical Equipment for Oil-Field Operation
☐ 31-129	J. J. Pilliod	Intercontinental Radiotelephone Service from the United States
☐ 31-130	E. A. Crellin	The Mokelumne River Development
☐ 31-131	E. M. Wright and B. D. Dexter	Power Transmission and Distribution From the Mokelumne River Development of the Pacific Gas and Electric Company
☐ 31M1	C. E. Carey and K. L. Howe	Electric Power in the Wood-Products Industry
☐ 31M2	S. B. Clark	A-C. Networks in Portland, Oregon
☐ 31M3	C. F. Green	Electrical Solutions of Problems of Regular Scheduled Flight
☐ 31M4	H. P. Boardman	Snow Surveys and Hydro-Forecasting
☐ 31M5	S. S. Mackeown	Cathode Drop in Arcs and Glow Discharges
☐ 31M6	A. L. Albert and W. R. Bullis	Electrical Measurements of Sound-Absorption
☐ 31M7	Vaino Hoover	Correlation of Induction Motor Design Factors

Papers presented prior to September 1931 upon which articles in this issue are based

Number	Author	Title
☐ 31-25	Philip Sporn and H. P. St. Clair	Oil Circuit Breaker Tests—Philo 1930, Aims, Set-up and Results From a System and Operating Viewpoint
☐ 31-26	R. M. Spurck and H. E. Strang	Circuit-Breaker Field Tests on Standard and Oil-Blast Explosion Chamber Oil Circuit Breakers
☐ 31-27	B. M. Pickens	Inclined-Catenary Calculations
☐ 31-39	R. C. Bergvall	Series Resistance Methods of Increasing Transient Stability Limits
☐ 31-51	N. F. Clement and E. E. Richards	Design of Catenary System for Cleveland Union Terminal
☐ 31-62	E. W. Griffith	Telegraph Power Plants

*Members, Enrolled Students, and subscribers are entitled to one pamphlet copy of any paper in this list if requested within one year from above date. Thereafter a charge of twenty-five cents per copy will obtain.

Name...

Address...

Please order papers by number. *Address* **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

Officers and Committees for 1931-32

President

(Term expires July 31, 1932)
C. E. SKINNER

Junior Past-Presidents

(Term expires July 31, 1932)
HAROLD B. SMITH

(Term expires July 31, 1933)
W. S. LEE

Vice-Presidents

(Terms expire July 31, 1932)
H. V. CARPENTER (District No. 9)
G. C. SHAAD (District No. 7)
I. E. MOULTROP (District No. 1)
H.P. CHARLESWORTH (District No. 3)
T. N. LACY (District No. 5)

(Terms expire July 31, 1933)
A. W. COPLEY (District No. 8)
W. B. KOUWENHOVEN (District No. 2)
W. E. FREEMAN (District No. 4)
P. H. PATTON (District No. 6)
L. B. CHUBBUCK (District No. 10)

Directors

(Terms expire July 31, 1932)
J. ALLEN JOHNSON
A. M. MacCUTCHEON
A. E. BETTIS

(Terms expire July 31, 1933)
J. E. KEARNS
F. W. PEEK, JR.
C. E. STEPHENS

(Terms expire July 31, 1934)
A. B. COOPER
A. E. KNOWLTON
R. H. TAPSCOTT

(Terms expire July 31, 1935)
L. W. CHUBB
H. R. WOODROW
B. D. HULL

National Treasurer

(Term expires July 31, 1932)
W. I. SLICHTER

National Secretary

(Term expires July 31, 1932)
F. L. HUTCHINSON

General Counsel

PARKER & AARON
20 Exchange Place, New York, N. Y.

Local Honorary Secretaries

T. J. Fleming, Calle B. Mitre 519, Buenos Aires, Argentina, S. A.

H. W. Flashman, Aus. Westinghouse Elec. Co., Ltd., Cathcart House, 11 Castlereagh St., Sydney, N. S. W., Australia.

F. M. Servos, Rio de Janeiro Tramways Lt. & Pr. Co., Rio de Janeiro, Brazil, S. A.

A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.

A. S. Garfield, 173 Boulevard Haussmann, Paris (8e), France.

B. C. Battye, Punjab P. W. D., Hydroelectric Branch, Kapurthala House, Lahore, India.

Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.

P. H. Powell, Canterbury College, Christchurch, New Zealand.

M. A. Chatelain, Polytechnical Institute, Apt. 27, Leningrad, Sosnowka 1-3, U. S. S. R.

A. F. Enstrom, Ingeniorsvetenskapsakademien, Stockholm, 5, Sweden.

W. Elsdon-Dew, P. O. Box 4563, Johannesburg, Transvaal, Africa.

GENERAL COMMITTEES

Executive Committee

C. E. Skinner, Chairman, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
H. P. Charlesworth,
J. A. Johnson,
W. S. Lee,
F. W. Peek, Jr.,
W. I. Slichter,
C. E. Stephens.

Board of Examiners

H. Goodwin, Jr., Chairman, 601 Franklin Bldg., Philadelphia, Pa.
H. E. Farrer, Secretary, 33 W. 39th St., New York, N. Y.
H. A. Currie,
H. W. Drake,
S. P. Grace,
H. A. Kidder,
F. V. Magalhaes,
R. H. Marriott,
L. W. W. Morrow,
A. L. Powell,
W. R. Smith,
S. D. Sprong,
R. H. Tapscott.

Finance Committee

C. E. Stephens, Chairman, Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.
H. P. Charlesworth,
R. H. Tapscott,

Publication Committee

E. B. Meyer, Chairman, 80 Park Place, Newark, N. J.
F. A. Lewis, Secretary, 33 W. 39th St., New York, N. Y.
W. S. Gorsuch,
W. H. Harrison,
F. L. Hutchinson,
H. R. Woodrow.

Meetings and Papers Committee

W. H. Harrison, Chairman, Am. Tel. & Tel. Co., 195 Broadway, New York, N. Y.
C. S. Rich, Secretary, 33 W. 39th St., New York, N. Y.
V. Bush,
W. S. Gorsuch,
W. B. Kouwenhoven,
Paul MacGahan,
T. A. Worcester

Ex-officio

Chairman of Committee on Coordination of Institute Activities.

Chairman of Technical Committees.

Sections Committee

E. S. Lee, Chairman, General Electric Co., Schenectady, N. Y.
W. B. Kouwenhoven,
G. H. Quermann,
I. M. Stein,
W. H. Timbie.

Ex-officio

Chairmen of Sections.

Membership Committee

R. L. Kirk, Chairman, Duquesne Light Co., Pittsburgh, Pa.
E. P. Coles,
F. G. Graf,
J. Harrison,
V. L. Hollister,
J. A. Johnson,
C. H. Kline,
J. A. Koontz,
T. G. LeClair,
D. W. Proebstel,
I. M. Stein,
E. M. Wood.

Ex-officio

Chairmen of Section membership committees.

Law Committee

W. S. Gorsuch, Chairman, 600 West 59th Street, New York, N. Y.
C. O. Bickelhaupt,
H. A. Kidder,
E. B. Meyer,
W. I. Slichter.

Committee on Coordination of Institute Activities

H. P. Charlesworth, Chairman, 463 West Street, New York, N. Y.
W. S. Gorsuch,
W. H. Harrison,
F. L. Hutchinson,
E. S. Lee,
E. B. Meyer,
C. E. Stephens.

Committee on Student Branches

W. H. Timbie, Chairman, Massachusetts Institute of Technology, Cambridge, Mass.
W. E. Freeman,
F. O. McMillan,
C. F. Scott,
W. J. Seeley.

Ex-officio

Student Branch Counselors.

Headquarters Committee

R. H. Tapscott, Chairman, New York Edison Co., 4 Irving Place, New York, N. Y.
F. L. Hutchinson,
C. E. Stephens.

Public Policy Committee

B. Gherardi, Chairman, Am. Tel. & Tel. Co., 195 Broadway, New York, N. Y.
C. C. Chesney,
F. B. Jewett,
W. S. Lee,
F. Osgood,
H. J. Ryan,
R. F. Schuchardt.

Standards Committee

A. M. MacCutcheon, Chairman, Reliance Electric & Engineering Co., 1088 Ivanhoe Road, Cleveland, Ohio.
H. E. Farrer, Secretary, 33 W. 39th St., New York, N. Y.
A. B. Cooper,
J. E. Goodale,
C. R. Harte,
J. F. Meyer,
V. M. Montsinger,
F. D. Newbury,
L. T. Robinson,
W. I. Slichter.

Ex-officio

Chairmen of Working Committees.

Chairmen of A. I. E. E. delegations and representatives on other standardizing bodies.

President of U.S. National Committee of I. E. C.

Edison Medal Committee

Appointed by the President for term of five years.

(Terms expire July 31, 1932)
H. P. Charlesworth,
P. M. Lincoln,
C. E. Stephens.

(Terms expire July 31, 1933)
D. C. Jackson, Chairman.
C. F. Harding,
F. A. Scheffler.

(Terms expire July 31, 1934)
L. W. W. Morrow,
W. S. Rugg,
R. F. Schuchardt.

(Terms expire July 31, 1935)
C. I. Burkholder,
F. A. Gaby,
H. J. Ryan.

(Terms expire July 31, 1936)
E. B. Meyer,
L. T. Robinson,
P. H. Thomas.

Appointed by the Board of Directors from its own membership for term of two years.

(Terms expire July 31, 1932)
A. E. Knowlton,
H. B. Smith,
R. H. Tapscott.

(Terms expire July 31, 1933)
J. E. Kearns,
W. S. Lee,
F. W. Peek, Jr.

Ex-officio

(Terms expire July 31, 1932)
C. E. Skinner, President,
W. I. Slichter, National Treasurer,
F. L. Hutchinson, National Secretary.

Lamme Medal Committee

(Terms expire July 31, 1932)
C. C. Chesney, Chairman.
H. P. Charlesworth,
R. B. Williamson.

(Terms expire July 31, 1933)
R. D. Mershon,
J. C. Smith,
P. H. Thomas.

(Terms expire July 31, 1934)
B. A. Behrend,
A. M. Dudley,
J. C. Parker.

Committee on Code of Principles of Professional Conduct

R. F. Schuchardt, Chairman, 72 West Adams Street, Chicago, Ill.

A. H. Babcock,
G. Faccioli,
F. B. Jewett,
W. E. Mitchell,
C. E. Stephens,
J. B. Whitehead.

Committee on Award of Institute Prizes

W. H. Harrison, Chairman, Am. Tel. & Tel. Co., 195 Broadway, New York, N. Y.

L. W. Chubb,
A. E. Knowlton,
E. B. Meyer.

Committee on Safety Codes

J. C. Forsyth, Chairman, New York Board of Fire Underwriters, 85 John Street, New York, N. Y.

A. W. Berresford,
L. B. Chubbuck,
J. F. Fairman,
H. B. Gear,
F. D. Knight,
M. G. Lloyd,
Wills Maclachlan,
F. V. Magalhaes,
J. D. Noyes,
F. A. Pattison,
H. R. Sargent,
Frank Thornton,
H. S. Warren.

Committee on Columbia University Scholarships

W. I. Slichter, Chairman, Columbia University, New York.

F. Blossom,
H. C. Carpenter.

Committee on Legislation Affecting the Engineering Profession

H. A. Kidder, Chairman, 600 West 59th Street, New York, N. Y.

J. P. Alexander,
T. F. Barton,
B. M. Brigman,
H. P. Charlesworth,
L. F. Leurey,
L. W. W. Morrow,
J. C. Parker,
J. R. Price,
H. S. Sands,
M. R. Scharff,
H. H. Schoolfield,
W. I. Slichter,
J. B. Thomas.

Committee on the Economic Status of the Engineer

C. O. Bickelhaupt, Chairman, Am. Tel. & Tel. Co., 195 Broadway, New York, N. Y.

W. S. Lee,
E. W. Rice, Jr.,
W. S. Rugg,
C. F. Scott.

Advisory Committee to the Museum of Science and Industry in the City of New York

J. P. Jackson, Chairman, New York Edison Co., 4 Irving Place, New York, N. Y.

C. O. Bickelhaupt,
R. H. Nexsen.

Committee on Popular Science Award

F. W. Peek, Jr., Chairman, General Electric Co., Pittsfield, Mass.

W. H. Harrison,
C. E. Stephens.

TECHNICAL COMMITTEES

Automatic Stations

D. W. Taylor, Chairman, United Engineers & Constructors, Inc., 80 Park Place, Newark, N. J.

F. F. Ambuhl,
L. D. Bale,
C. W. Colvin,
C. F. Craig,
A. M. Garrett,
Joseph Hellenthal
Chester Lichtenberg,
C. A. Mayo,
I. E. Moultrop,
M. E. Reagan,
O. J. Rotty,
Garland Stamper,
L. J. Turley,
F. Zogbaum.

Communication

H. S. Osborne, Chairman, Am. Tel. & Tel. Co., 195 Broadway, New York, N. Y.

H. M. Bascom,
E. L. Bowles,
W. H. Capen,
A. A. Clokey,
R. N. Conwell,
C. F. Craig,
B. R. Cummings,
I. C. Forshee,
D. H. Gage,
B. D. Hull,
G. M. Keenan,
G. A. Kositzky,
C. J. Larsen,
John Mills,
J. W. Milnor,
E. J. O'Connell,
Frederick A. Raymond,
H. A. Shepard,
Emmett R. Shute,
A. L. Stadermann,
C. H. Taylor,
H. M. Turner,
F. A. Wolff.

Education

R. E. Doherty, Chairman, Yale University, New Haven, Conn.

R. W. Adams,
M. W. Alexander,
E. W. Allen,
J. W. Barker,
Edward Bennett,
P. S. Biegler,
H. V. Carpenter,
C. S. Coler,
C. R. Dooley,
H. E. Dyche,
O. W. Eshbach,
O. J. Ferguson,
H. H. Henline,
A. H. Lovell,
H. W. Price,
W. T. Ryan,
G. B. Thomas,
W. H. Timbie,
W. E. Wickenden.

Electrical Machinery

P. L. Alger, Chairman, General Electric Co., Schenectady, N. Y.

B. L. Barns,
E. S. Bundy,
H. E. Edgerton,
J. E. Goodale,
T. T. Hambleton,
A. L. Harding,
C. F. Harding,
E. W. Henderson,
S. L. Henderson,
L. F. Hickernell,
J. A. Johnson,
J. J. Linebaugh,
H. C. Louis,
A. M. MacCutcheon,
O. K. Marti,
V. M. Montsinger,
E. L. Moreland,
R. W. Owens,
R. H. Park,
E. B. Paxton,
H. V. Putnam,
K. A. Reed,
A. M. Rossman,
O. E. Shirley,
R. G. Warner,
C. A. M. Weber,
R. B. Williamson.

Electric Welding

P. P. Alexander, Chairman, General Electric Co., River Works, West Lynn, Mass.

C. A. Adams,
A. M. Candy,
Alexander Churchward,
F. Creedy,
S. Dushman,
K. L. Hansen,
H. M. Hobart,
R. G. Hudson,
J. E. Kearns,
J. C. Lincoln,
Ernest Lunn,
F. C. Owen,
J. Slepian,
W. Spraragen,
H. E. Stoddard,
H. W. Tobey,
G. H. Winkler.

Electrochemistry and Electrometallurgy

(To be appointed)

Electrophysics

V. Bush, Chairman, Mass. Inst. of Tech., Cambridge A, Mass.

O. E. Buckley,
W. G. Cady,
W. F. Davidson,
L. O. Grondahl,
W. B. Kouwenhoven,
B. E. Lenehan,
G. M. J. Mackay,
S. S. Mackeown,
K. B. McEachron,
L. W. McKeehan,
H. Nyquist,
J. Slepian.
W. C. White.

Liaison Representatives of American Physical Society

Prof. Leigh Page,
Dr. W. F. G. Swann.

General Power Applications

C. W. Drake, Chairman, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A. H. Albrecht,
E. A. Armstrong,
James Clark, Jr.,
J. F. Gaskill,
John Grotzinger,
T. Hibbard,
Fraser Jeffrey,
A. M. MacCutcheon,
H. A. Maxfield,
John Morse,
N. L. Mortensen,
A. M. Perry,
D. M. Petty,
H. W. Rogers,
L. D. Rowell,
W. K. Vandorpool,
M. R. Woodward.

Instruments and Measurements

E. J. Rutan, Chairman, New York Edison Co., 92 Vandam Street, New York, N. Y.

H. S. Baker,
O. J. Bliss,
P. A. Borden,
H. B. Brooks,
A. L. Cook,
E. D. Doyle,
W. W. Eberhardt,
Marion Eppley,
J. B. Gibbs,
W. N. Goodwin, Jr.,
I. F. Kinnard,
O. A. Knopp,
A. E. Knowlton,
H. C. Koenig,
W. B. Kouwenhoven,
F. A. Laws,
E. S. Lee,
J. B. Lunsford,
Paul MacGahan,
R. T. Pierce,
W. J. Shackelton,
H. L. Thomson,
H. M. Turner.

Applications to Iron and Steel Production

A. C. Cummins, Chairman, Carnegie Steel Co., Duquesne, Pa.

F. B. Crosby,
Wray Dudley,
J. E. Fries,
S. L. Henderson,
A. M. MacCutcheon,
F. O. Schnure,
W. B. Shirk,
G. E. Stoltz,
T. S. Towle,
H. A. Winne.

Production and Application of Light

W. T. Blackwell, Chairman, 80 Park Place, Newark, N. J.

J. W. Barker,
A. E. Bettis,
H. S. Broadbent,
J. M. Bryant,
W. T. Dempsey,
R. E. Dorting,
L. A. Hawkins,
H. H. Higbie,
C. L. Kinsloe,
R. D. Mailey,
G. S. Merrill,
P. S. Millar,
P. H. Moon,
C. M. Moss,
R. E. Simpson,
G. H. Stickney.

Applications to Marine Work

R. A. Beekman, Chairman, General Electric Co., Schenectady, N. Y.

E. C. Alger,
H. C. Coleman,
E. M. Glasgow,
H. F. Harvey, Jr.,
C. J. Henschel,
W. Hetherington, Jr.,
H. L. Hibbard,
J. E. Kearns,
A. Kennedy, Jr.,
J. B. Lunsford,
I. H. Osborne,
G. A. Pierce,
W. H. Reed,
E. P. Slack,
H. M. Southgate,
W. E. Thau,
John Van der Dussen,
A. E. Waller,
O. A. Wilde,
C. L. Wilson,
R. L. Witham,
W. N. Zippler.

Applications to Mining Work

D. E. Renshaw, Chairman, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A. R. Anderson,
Graham Bright,
J. H. Edwards,
E. J. Gealy,
L. C. Ilsley,
J. E. Kearns,
Carl Lee,
W. H. Lesser,
C. W. Parkhurst,
F. L. Stone,
J. F. Wiggert,
C. D. Woodward.

Power Generation

J. R. Baker, Chairman, 1611 Lexington Building, Baltimore, Md.

F. A. Allner,
F. A. Annett,
D. S. Brown,
A. Carnegie,
H. E. Clifford,
J. B. Crane,
B. D. Dexter,
R. D. DeWolf,
W. P. Dryer,
N. E. Funk,
W. S. Gorsuch,
F. C. Hanker,
L. F. Harza,
J. V. L. Hogan,
F. H. Hollister,
A. H. Hull,
H. W. Leitch,
A. N. Lovell,
E. B. Meyer,
I. E. Moultrop,
F. A. Scheffler,
F. O. Schnure,
A. E. Silver,
Arthur R. Smith.

Power Transmission and Distribution

P. H. Chase, Chairman, Philadelphia Electric Co., 900 Sansom Street, Philadelphia, Pa.

Sydney Alling,
E. J. Amberg,
F. E. Andrews,
A. B. Campbell,
C. V. Christie,
R. N. Conwell,
A. E. Davison,
H. C. Dean,
L. L. Elden,
R. D. Evans,
F. M. Farmer,
Edwin Hansson,
K. A. Hawley,
L. F. Hickernell,
D. C. Jackson, Jr.,
J. P. Jollyman,
A. H. Lawton,
I. E. Moultrop,
L. L. Perry,
T. F. Peterson,
D. W. Roper,
A. E. Silver,
D. M. Simmons,
C. T. Sinclair,
L. G. Smith,
H. H. Spencer,
Philip Sporn,
W. K. Vanderpoel,
C. F. Wagner,
H. S. Warren,
T. A. Worcester.

Protective Devices

Raymond Bailey, Chairman, Philadelphia Electric Co., 900 Sansom Street, Philadelphia, Pa.

G. O. Bason,
A. W. Copley,
S. L. Goldsborough,
R. T. Henry,
E. A. Hester,
L. F. Hickernell,
T. G. LeClair,
J. B. MacNeill,
J. P. McKearin,
H. A. McLaughlin,
D. M. Petty,
H. J. Scholz,
H. K. Sels,
Wm. Shuler,
H. P. Sleeper,
L. G. Smith,
E. R. Stauffacher,
H. R. Summerhayes,
O. C. Traver,
E. M. Wood,
H. B. Wood.

Research

L. W. Chubb, Chairman, Westinghouse Electric & Mfg. Co., East Pittsburgh Pa.

H. D. Arnold,
Edward Bennett,
W. G. Cady,
E. H. Colpitts,
E. C. Crittenden,
W. F. Davidson,
W. P. Dobson,
F. M. Farmer,
V. Karapetoff,
A. E. Kennelly,
J. K. McNeely,
F. W. Peek, Jr.,
H. H. Race,
C. W. Rice,
D. W. Roper,
T. Spooner,
J. B. Whitehead,
R. J. Wiseman.

Transportation

E. L. Moreland, Chairman, Jackson and Moreland, 31 St. James Avenue, Boston, Mass.

Reinier Beeuwkes,
A. E. Bettis,
H. A. Currie,
J. V. B. Duer,
H. H. Field,
I. W. Fisk,
K. T. Healy,
H. N. Latey,
John Murphy,
H. Parodi,
W. B. Potter,
R. H. Rice,
S. A. Spalding,
N. W. Storer,
W. M. Vandersluis,
R. P. Winton,
Sidney Withington,
G. I. Wright.

INSTITUTE REPRESENTATIVES

Aeronautic Radio Research, Liaison Committee on

Ray H. Manson.

Alfred Noble Prize Committee

A. E. Knowlton.

American Association for the Advancement of Science Council

L. M. Klauber, C. E. Skinner.

American Bureau of Welding

H. M. Hobart.

American Committee on Electrolysis

B. J. Arnold, N. A. Carle,
F. N. Waterman.

American Engineering Council Assembly

A. W. Berresford,
*C. O. Bickelhaupt,
F. J. Chesterman,
M. M. Fowler,
F. L. Hutchinson,
*H. A. Kidder,
W. S. Lee,
William McClellan,
L. F. Morehouse,
I. E. Moultrop,
Farley Osgood,
W. S. Rodman,
*R. F. Schuchardt,
*Charles F. Scott,
*C. E. Skinner,
Harold B. Smith,
C. E. Stephens,
L. B. Stillwell.

*Representatives on Administrative Board.

American Marine Standards Committee

R. A. Beekman.

American Standards Association Board of Directors

B. Gherardi.

Council

F. D. Newbury, John C. Parker,
L. T. Robinson.

Alternates

H. H. Henline, H. M. Hobart,
H. S. Osborne.

American Year Book, Advisory Board

Henry H. Henline.

Charles A. Coffin Fellowship and Research Fund Committee

C. E. Skinner.

Committee of Apparatus Makers and Users, National Research Council

L. T. Robinson.

Committee on Elimination of Fatigue, Society of Industrial Engineers

C. Francis Harding.

Committee on Heat Transmission, National Research Council

T. S. Taylor.

Electrical Standards Committee, A. S. A.

H. P. Charlesworth, F. D. Newbury,
L. T. Robinson.

Engineering Foundation Board

C. E. Skinner, W. I. Slichter.

Engineering Societies Monographs Committee

E. B. Meyer, W. I. Slichter.

Hoover Medal Board of Award

Gano Dunn, F. B. Jewett,
E. W. Rice, Jr.

John Fritz Medal Board of Award

Bancroft Gherardi, R. F. Schuchardt,
W. S. Lee, Harold B. Smith.

Joint Committee on Welded Rail Joints

D. D. Ewing.

Joint Conference Committee of Founder Societies

The Presidents and Secretaries, *ex-officio*.

Library Board, United Engineering Trustees, Inc.

W. S. Barstow, F. L. Hutchinson,
W. A. Del Mar, W. B. Jackson,
W. I. Slichter.

National Fire Protection Association, Electrical Committee

J. C. Forsyth, F. V. Magalhaes,
Alternate.

National Fire Waste Council

J. C. Forsyth, F. V. Magalhaes.

National Research Council, Engineering Division

H. P. Charlesworth, F. W. Peek, Jr.,
C. E. Skinner.
F. L. Hutchinson, *ex-officio.*

National Safety Council, A. S. S. E.—Engineering Section

J. C. Forsyth.

Radio Advisory Committee, Bureau of Standards

A. E. Kennelly.

United Engineering Trustees, Inc., Board of Trustees

H. P. Charlesworth, H. A. Kidder,
G. L. Knight.

U. S. National Committee of the International Commission on Illumination

A. E. Kennelly, C. O. Mailloux,
Clayton H. Sharp.

U. S. National Committee of the International Electrotechnical Commission

L. F. Adams,
E. W. Allen,
James Burke,
W. A. Del Mar,
Gano Dunn,
F. C. Hanker,
C. R. Harte,
H. M. Hobart
D. C. Jackson,
F. B. Jewett,
A. E. Kennelly,
A. M. MacCutcheon (*ex-officio*),
C. O. Mailloux,
William McClellan,
J. F. Meyer,
H. S. Osborne,
Farley Osgood,
F. W. Peek, Jr.,
Harold Pender,
L. T. Robinson,
C. H. Sharp,
C. E. Skinner,
W. I. Slichter,
C. E. Stephens (*ex-officio*),
N. W. Storer,
J. W. Upp.

Commission of Washington Award

L. A. Ferguson, Charles F. Scott.

Geographical District Executive Committees

District	Chairman (Vice-President, A. I. E. E.)	Secretary (District Secretary)
No. 1—North Eastern	I. E. Moultrop, Edison Elec. Illum. Co., 39 Boylston St., Boston, Mass.	A. C. Stevens, General Electric Co., Schenectady, N. Y.
No. 2—Middle Eastern	W. B. Kouwenhoven, Johns Hopkins University, Baltimore, Md.	George S. Diehl, Pennsylvania Water & Power Co., 1611 Lexington Building, Baltimore, Md.
N . 3—New York City	H. P. Charlesworth, 463 West St., New York, N. Y.	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
No. 4—Southern	W. E. Freeman, University of Kentucky, Lexington, Ky.	E. A. Bureau, University of Kentucky, Lexington, Ky.
No. 5—Great Lakes	T. N. Lacy, Mich. Bell Tel. Co., 1365 Cass Ave., Detroit, Mich.	A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis, Minn.
No. 6—North Central	P. H. Patton, Northwestern Bell Tel. Co., Telephone Building, Omaha, Neb.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. C. Shaad, University of Kansas, Lawrence, Kans.	R. W. Warner, University of Kansas, Lawrence, Kans.
No. 8—Pacific	A. W. Copley, Westinghouse Elec. & Mfg. Co., 1 Montgomery St., San Francisco, Calif.	C. E. Baugh, 245 Market St., San Francisco, Calif.
No. 9—North West	H. V. Carpenter, State College of Washington, Pullman, Wash.	R. D. Sloan, State College of Washington, Pullman, Wash.
No. 10—Canada	L. B. Chubbuck, Canadian Westinghouse Co., Hamilton, Ont.	W. L. Amos, Hydro-Elec. Pr. Com., 190 University Ave., Toronto, Ont.

Note: Each District Executive Committee includes the chairmen and secretaries of all Sections within the District and the chairman of the District Committee on Student Activities.

Local Sections of the Institute

Name	District	Chairman	Secretary	Secretary's Address
Akron	2	R. R. Krammes	R. A. Hudson	Goodyear Zeppelin Corp., Akron, Ohio
Atlanta	4	A. G. Stanford	J. H. Persons	General Electric Co., Atlanta, Ga.
Baltimore	2	K. A. Hawley	J. Wells	Western Electric Co., Baltimore, Md.
Birmingham	4		O. E. Charlton	Allied Engineers, Inc., Birmingham, Ala.
Boston	1	C. A. Corney	G. J. Crowdes	Simplex Wire & Cable Co., Cambridge, Mass.
Chicago	5	F. R. Innes	E. C. Williams	20 North Wacker Drive, Chicago, Ill.
Cincinnati	2	E. S. Fields	J. A. Noertker	Cincinnati Street Railway Co., Cincinnati, Ohio
Cleveland	2	G. A. Kositzky	F. E. Snell	Cleveland Railway Co., Cleveland, Ohio
Columbus	2	W. L. Everitt	Roy Mallory	Ohio Bell Tel. Co., Columbus, Ohio
Connecticut	1	R. G. Warner	W. B. Hall	Yale University, New Haven, Conn.
Dallas	7	Gibbs A. Dyer	S. M. Sharp	1100 Allen Bldg., Dallas, Tex.
Denver	6	R. E. Nyswander	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	J. J. Shoemaker	O. E. Hauser	Detroit Edison Co., Detroit, Mich.
Erie	2	P. R. Urich	C. V. Roberts	Erie Lighting Co., 21-23 West 10th St., Erie, Pa.
Florida	4	Joseph Weil	R. P. Smith	P. O. Box 2574, Jacksonville, Fla.
Fort Wayne	5	E. J. Schaefer	C. M. Summers	General Elec. Co., Fort Wayne, Ind.
Houston	7	E. M. Wise	J. S. Waters	Rice Institute, Houston, Texas
Indianapolis-Laf	5	E. L. Carter	E. G. Thoms	Indiana Bell Tel. Co., Indianapolis, Ind.
Iowa	5	H. B. Hoffhaus	E. W. Schilling	Iowa State College, Ames, Iowa
Ithaca	1	W. E. Meserve	B. K. Northrop	Cornell Univ., Ithaca, N. Y.
Kansas City	7	George Fiske	R. M. Ryan	General Electric Co., Kansas City, Mo.
Lehigh Valley	2	Morland King	J. H. Diefenderfer	Penna. Pr. & Lt. Co., Hazleton, Pa.
Los Angeles	8	P. S. Biegler	F. E. Dellinger	Los Angeles Gas & Elec. Corp., Los Angeles, Calif.
Louisville	4	P. P. Ash	C. M. Ewing	Louisville Gas & Elec. Co., Louisville, Ky.
Lynn	1	J. A. Cook	G. R. Sturtevant	General Electric Co., Lynn, Mass.
Madison	5	N. H. Blume	G. F. Tracy	University of Wisconsin, Madison, Wis.
Memphis	4	M. Eldredge	W. A. Gentry	Memphis Power & Light Co., Memphis, Tenn.
Mexico	3	B. F. Arias	L. Castro, Jr.	Departamento Electricidad y Telegrafos, Ferrocarriles Nacionales de Mex., Mexico, D. F.
Milwaukee	5	C. H. Krueger	E. U. Lassen	Cutler Hammer, Inc., Milwaukee, Wis.
Minnesota	5	Oscar Gaarden	E. H. Hagensick	The Pyle-National Co., St. Paul, Minn.
Nebraska	6	A. L. Turner	C. Talsma	610 Electric Building, Omaha, Nebraska
New York	3	O. H. Caldwell	H. C. Dean	N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.
Niagara Frontier	1	R. W. Graham	G. W. Eighmy	General Electric Co., 1100 Electric Bldg., Buffalo, N. Y.
North Carolina	4	J. H. Paget	F. C. DeWeese	Carolina Pr. & Lt. Co., Raleigh, N. C.
Oklahoma City	7	C. T. Almquist	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	C. N. Johnson	J. L. MacBurney	Elec. Storage Battery Co., Philadelphia, Pa.
Pittsburgh	2	F. A. Conner	T. Spooner	Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Pittsfield	1	F. R. Finch	K. B. Van Tassel	General Electric Co., Pittsfield, Mass.
Portland, Ore.	9	R. J. Davidson	F. M. Lewis	Northwestern Electric Co., Public Serv. Bldg., Portland, Ore.
Providence	1	W. S. Maddocks	O. W. Briden	Blackstone Valley Gas & Elec. Co., Pawtucket, R. I.
Rochester	1	F. C. Young	E. K. Huntington	Rochester Gas & Elec. Corp., Rochester, N. Y.
St. Louis	7	C. H. Kraft	C. H. Lankford	Century Electric Co., 1806 Pine St., St. Louis, Mo.
San Antonio	7	J. E. Woods	D. E. Woods	P. O. Box 1105, San Antonio, Texas
San Francisco	8	E. A. Crellin	W. C. Smith	872 Russ Bldg., San Francisco, Calif.
Saskatchewan	10	W. T. Hunt	A. B. Coward	Light & Power Dept., Regina, Sask., Can.
Schenectady	1	R. A. Beekman	E. P. Nelson	General Electric Co., Schenectady, N. Y.
Seattle	9	M. T. Crawford	C. B. Carpenter	Pacific Tel. & Tel. Co., Dexter Horton Bldg., Seattle, Wash.
Sharon	2	R. M. Field	A. M. Wiggins	Westinghouse E. & M. Co., Sharon, Pa.
Southern Virginia	4	J. H. Berry	E. L. Lockwood	Virginia Public Service Co., Newport News, V .
Spokane	9	H. L. Vincent	W. M. Allen	Home Tel. & Tel. Co., Spokane, Wash.
Springfield, Mass	1	B. V. K. French	L. C. Packer	Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Syracuse	1	C. W. Henderson	W. E. Mueller	Denison & Thompson, Syracuse, N. Y.

Local S ctions of the Institute—Continu d

Name	District	Chairman	Secretary	Secretary's Address
Toledo	2	J. A. Dinwiddie	Max Neuber	1257 Fernwood Ave., Toledo, Ohio
Toronto	10	T. W. Eadie	G. D. Floyd	Hydro Elec. Pr. Comm., 190 Univ. Ave., Toronto, Ont.
Urbana	5	E. H. Waldo	E. A. Reid	University of Illinois, Urbana, Ill.
Utah	9	Paul Ransom	A. L. Taylor	Univ. of Utah., Salt Lake City, Utah
Vancouver	10	G. R. Wright	C. Arnott	B. C. Elec. Railway Co., Ltd., Vancouver, B. C., Canada
Washington	2	G. L. Weller	C. M. Brown	Westinghouse Elec. & Mfg. Co., Washington, D. C.
Worcester	1	J. P. McCann	R. P. Bullen	General Electric Co., Worcester, Mass.
Total 59				

Student Branches of the Institute

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Akron, Univ. of	Akron, Ohio	2	Harmon Shively	H. H. Schroeder	J. T. Walther
Alabama, Poly. Inst	Auburn, Ala	4	W. H. Minns	G. F. Fuker	W. W. Hill
Alabama, Univ. of	University, Ala	4	Walter H. Croft	H. B. Hendrix	F. R. Maxwell, Jr.
Arizona, Univ. of	Tucson, Ariz	8	P. F. Hawley	T. S. Henderson	J. C. Clark
Arkansas, Univ. of	Fayetteville, Ark	7	Harold D. Albrecht	Robert Vining	W. B. Stelzner
Armour Inst. of Tech	Chicago, Ill	5	W. J. Jost	R. H. Frye	E. H. Freeman
British Columbia, Univ. of	Vancouver, B. C	10	D. S. Smith	H. M. Van Allen	E. G. Cullwick
Brooklyn, Poly. Inst. of	Brooklyn, N. Y	3	George Morton	F. Anderson	H. B. Hanstein
Bucknell Univ	Lewisburg, Pa	2	O. R. Sterling	P. Hort	George A. Irland
Calif. Inst. of Tech	Pasadena, Calif	8	P. B. Lyons	R. W. St. Clair	R. W. Sorensen
Calif., Univ. of	Berkeley, Calif	8	V. T. Johnson	Hilas C. Ashley	L. E. Reukema
Carnegie Inst. of Tech	Pittsburgh, Pa	2	W. B. Wigton	F. A. Lennberg	George Porter
Case Sch. of Ap. Science	Cleveland, Ohio	2	W. J. Lattin	K. R. Spangenberg	H. B. Dates
Catholic Univ. of America	Washington, D. C	2	David E. Doody	F. D. Vezzos	T. J. MacKavanagh
Cincinnati, Univ. of	Cincinnati, Ohio	2	W. Kock	Henry Suter	W. C. Osterbrock
Clarkson College of Tech	Potsdam, N. Y	1	C. O. McNairn	J. H. O'Rourke	A. R. Powers
Clemson Agri. College	Clemson College, S. C	4	H. S. Montgomery	C. A. Farish	S. R. Rhodes
Colorado State Agri. College	Ft. Collins, Colo	6	Leroy Sweet		F. L. Poole
Colorado, Univ. of	Boulder, Colo	6	F. W. Cooper	W. C. Spear	W. C. DuVall
Cooper Union	New York, N. Y	3	H. Grissler	A. B. Mundel	A. J. B. Fairburn
Cornell University	Ithaca, N. Y	1	Randall A. Smith	Wm. S. Bachman	E. M. Strong
Denver, Univ. of	Denver, Colo	6	L. C. Trussler	Irwin Olcovich	R. E. Nyswander
Detroit, Univ. of	Detroit, Mich	5	B. Sharkey	J. Schenk	H. O. Warner
Drexel Inst	Philadelphia, Pa	2	G. Koster	G. Metz	E. O. Lange
Duke Univ	Durham, N. C	4	S. G. Flack	J. A. Womack	W. J. Seeley
Florida, Univ. of	Gainesville, Fla	4	R. E. Walker	L. P. Barnett	Joseph Weil
Georgia School of Tech	Atlanta, Ga	4	J. H. Harrison	Jack S. Gantt	T. W. Fitzgerald
Harvard Univ	Cambridge, Mass	1	Eric A. Walker	Charles N. Mason	C. L. Dawes
Idaho, Univ. of	Moscow, Idaho	9	Glenn E. Gage	H. R. McBirney	R. H. Hull
Illinois, Univ. of	Urbana, Ill	5	W. P. Burglund	G. L. Bodwell	C. E. Skroder
Iowa State College	Ames, Iowa	5	W. L. Huebner	G. Franks	F. E. Johnson
Iowa, State Univ. of	Iowa City, Iowa	5	J. W. Campian	Don A. Cozine	E. B. Kurtz
Kansas State College	Manhattan, Kansas	7	G. E. Cain	D. E. West	R. G. Kloeffler
Kansas, Univ. of	Lawrence, Kansas	7	Edward Fisher	Jack Brous	D. C. Jackson, Jr.
Kentucky, Univ. of	Lexington, Ky	4	S. M. Worthington	B. G. Crosby, Jr	W. E. Freeman
Lafayette College	Easton, Pa	2	A. H. Edmondson	Henry H. Jones	Lawrence Conover
Lehigh Univ	Bethlehem, Pa	2	L. F. Underwood	C. W. Banks	N. S. Hibshman
Lewis Inst	Chicago, Ill	5	C. B. Frellsen	K. J. Sinclair	F. A. Rogers
Louisiana State Univ	Baton Rouge, La	4	Fred H. Fenn	R. A. Crain	M. B. Voorhies
Louisville, Univ. of	Louisville, Ky	4	John G. Lips	Wm. E. Bailey	S. B. Fife
Maine, Univ. of	Orono, Maine	1	Ronald E. Young	Roland J. Tibbetts	W. E. Barrows
Marquette Univ	Milwaukee, Wis	5	Ellsworth Ziehm	Donald Boehmer	Edward Kane
Massachusetts Inst. of Tech	Cambridge, Mass	1	John C. Gibson	Thomas R. Smith	W. H. Timbi
Michigan Col. of Mining and Tech	Houghton, Mich	5	A. G. Rogers	M. D. Crowell	G. W. Swenson
Michigan State College	East Lansing, Mich	5	Edwin W. Moore	Webster Bowler	W. A. Murray
Michigan, Univ. of	Ann Arbor, Mich	5	A. D. Forbes	G. Muffly	S. S. Attwood
Milwaukee, School of Eng. of	Milwaukee, Wis	5	Wm. P. Gainer	H. F. Volkmann	V. M. Murray
Minnesota, Univ. of	Minneapolis, Minn	5	M. G. Swanson	S. McDermott	J. H. Kuhlmann
Mississippi Agri. & Mech. Col	A. & M. College, Miss	4	J. M. Leigh	J. T. Young	L. L. Patterson
Missouri School of Mines & Met	Rolla, Mo	7	J. D. Shelton	G. L. Leisher	I. H. Lovett
Missouri, Univ. of	Columbia, Mo	7	R. L. Young	R. Osadchey	M. P. Weinbach
Montana State College	Bozeman, Mont	9	Homer Lambdin	Wesley C. Funk	J. A. Thaler
Nebraska, Univ. of	Lincoln, Neb	6	P. Ehrenhard	Wm. M. Ely	F. W. Norris
Nevada, Univ. of	Reno, Nevada	8	Donald Knapp	Orvis E. Reil	S. G. Palmer
Newark College of Eng	Newark, N. J	3	E. Olsta	J. G. Woehling	J. C. Peet
New Hampshire, Univ. of	Durham, N. H	1	P. A. Rolfe	R. H. Williams	L. W. Hitchcock
New Mexico, Univ. of	Albuquerque, New Mexico	7	M. Austin True	Stanley O. Fish	F. M. Denton
New York, Col. of the City of	New York, N. Y	3	A. Rosenberg	I. E. Lawlor	Harry Baum
New York Univ	Univ. Heights, New York, N. Y	3	L. E. Dinnar	G. M. Heckel	J. L. Arnold
North Carolina State College	Raleigh, N. C	4	G. E. Ritchie	L. C. Hubbard	R. S. Fouraker
North Carolina, Univ. of	Chapel Hill, N. C	4	D. J. Thurston, Jr.	Sam Barham	J. E. Lear
North Dakota Agri. College	Fargo, N. D	6	Clarence Bryant	Ralph Simenson	H. S. Rush
North Dakota, Univ. of	Grand Forks, N. D	6	B. J. Shields	Mark Scarff	H. F. Rice
Northeastern Univ	Boston, 17, Mass	1	A. K. Wright	P. H. Townsend	W. L. Smith
Notre Dame, Univ. of	Notre Dame, Ind	5	Hugh Ball	F. A. Consolati	J. A. Caparo
Ohio Northern Univ	Ada, Ohio	2	O. R. Jacobs	W. Gideon	I. S. Campbell

Student Branches of the Institute—Continued

Name	Location	District	Chairman	Secretary	Counselor (Member of Faculty)
Ohio State Univ	Columbus, Ohio	2	Charles L. Lucal	G. W. Moyer	F. C. Caldwell
Ohio Univ	Athens, Ohio	2	George Wyckoff	William Cooper	A. A. Atkinson
Oklahoma Agri. & Mech. College	Stillwater, Okla	7	Joe W. Hutchins	Clyde V. Benson	A. Naeter
Oklahoma, Univ. of	Norman, Okla	7	Chas. C. Ludwick	J. Strossberger	F. G. Tappan
Oregon State College	Corvallis, Ore	9	Dale Hansen	George Howie	F. O. McMillan
Pennsylvania State College	State College, Pa	2	J. N. Seiler	J. W. Hostetter	L. A. Doggett
Pennsylvania, Univ. of	Philadelphia, Pa	2	C. N. Maxfield	H. D. Sarkis	C. D. Fawcett
Pittsburgh, Univ. of	Pittsburgh, Pa	2	W. J. Howell	R. H. Kernahan	H. E. Dyche
Pratt Inst	Brooklyn, N. Y	3	Wm. H. Sutton	Ronald L. Bishop	C. C. Carr
Princeton Univ	Princeton, N. J	2	Frank L. Thomson	Ernest E. George	Malcolm MacLaren
Purdu Univ	Lafayette, Ind	5	P. O. Peterson	E. M. Sharer	A. N. Topping
Rensselaer Poly. Inst	Troy, N. Y	1	J. J. Lewis	H. A. Schlieder	F. M. Sebast
Rhode Island State College	Kingston, R. I	1	Leon C. Breault	Lloyd E. Crandall	William Anderson
Rice Inst	Houston, Texas	7	M. E. Kattmann	E. A. Turner, Jr	J. S. Waters
Rose Poly. Inst	Terre Haute, Ind	5	Robert Roach	Charles E. White	C. C. Knipmeyer
Rutgers Univ	New Brunswick, N. J	3	Fred T. Kent, Jr	W. M. Reiley	F. H. Pumphrey
Santa Clara, Univ. of	Santa Clara, Calif	8	L. W. Thorpe	T. Eberhard	E. F. Peterson
South Carolina, Univ. of	Columbia, S. C	4	L. E. Rankin	L. W. Dickinson, Jr	T. F. Ball
South Dakota State Sch. of Mines	Rapid City, S. D	6	Almon M. Bjerke		J. O. Kammerman
South Dakota, Univ. of	Vermillion, S. D	6	Myron Cole	Carl Bauman	B. B. Brackett
Southern California, Univ. of	Los Angeles, Calif	8	M. C. Marshall	Louis Bayha	W. G. Angermann
Southern Methodist Univ	Dallas, Texas	7	J. V. Melton	Porter Lindsley, Jr	H. F. Huffman
Stanford Univ	Stanford University, Calif	8	M. R. Jones, Jr	Ronald H. Born	
Stevens Inst. of Tech	Hoboken, N. J	3	G. J. Costello	F. F. Fuller	F. C. Stockwell
Swarthmore College	Swarthmore, Pa	2	Lewis Fussell, Jr	Robert H. Lamey	Lewis Fussell
Syracuse Univ	Syracuse, N. Y	1	Donald Robinson	W. Kleppinger	C. W. Henderson
Tennessee, Univ. of	Knoxville, Tenn	4	H. M. Patterson	C. T. Nunley	J. G. Tarboux
Texas Agri. & Mech. College	College Station, Texas	7	T. M. Sowell	E. A. Stobart	H. C. Dillingham
Texas Tech. College	Lubbock, Texas	7	Walter Burns	Everitt Dison	W. J. Miller
Texas, Univ. of	Austin, Texas	7	T. E. Cole	D. Sussin	J. A. Correll
Utah, Univ. of	Salt Lake City, Utah	9	R. C. Hansen	Wm. S. Nishiyama	A. LeRoy Taylor
Vermont, Univ. of	Burlington, Vt	1	Donald E. Child	Robert A. Hyde	L. P. Dickinson
Virginia Military Inst	Lexington, Va	4	J. C. Shell	E. R. Trapnell	S. W. Anderson
Virginia Poly. Inst	Blacksburg, Va	4	R. E. McDaniel		Claudius Lee
Virginia, Univ. of	University, Va	4	G. G. Quarles	T. J. Peterson	W. S. Rodman
Washington, State Col. of	Pullman, Wash	9	D. H. Olney	G. C. O'Brien	Orren E. Osburn
Washington Univ	St. Louis, Mo	7	Don A. Fischer	E. A. Wolff	W. L. Upson
Washington, Univ. of	Seattle, Wash	9	Allen S. Koch	F. Buckman	G. L. Hoard
West Virginia Univ	Morgantown, W. Va	2	P. J. Johnson	C. F. Stewart	A. H. Forman
Wisconsin, Univ. of	Madison, Wis	5	A. G. Woodford	T. N. Racheff	C. M. Jansky
Worcester Poly. Inst	Worcester, Mass	1	R. G. Driscoll	Wm. A. Ardito	C. D. Knight
Wyoming, Univ. of	Laramie, Wyo	6	Neil Sanders	Roy Perkins	G. H. Sechrist
Yale Univ	New Haven, Conn	1	Ludwig B. Hansen	F. M. Wolff	W. B. Hall
Total 109					

Affiliated Student Society

Brown Engineering Society	Brown Univ., Providence, R. I.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during July are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Business Adrift. By W. B. Donham. N. Y., McGraw-Hill Book Co., 1931. 165 pp., 9 x 6 in., cloth, $2.50.——A thoughtful, important contribution upon the problems that threaten our future economic well-being. The author discusses the part that business men must play in meeting the needs of the American people, and offers a plan for the future which will meet changing business conditions intelligently.

Aircraft Yearbook, 1931. Edit. by Aeronautical Chamber of Commerce. N. Y., D. Van Nostrand Co., 1931 607 pp., illus., diagrs., charts, maps, tables, 9 x 6 in., cloth, $6.00.——Reviews technical and commercial developments during the year. Describes the air lines in operation and the work of the army and navy, the activities of colleges, the changes in airplane design, legislation, etc. Drawings of all aircraft and engines in production are given, together with much statistical information.

Abfluss-Untersuchungen und-Berechnungen für Ueberfälle an Scharfkantigen Wehren. (Mitteilungen aus dem Gebiete des Wasserbaues und der Baugrundforschung, Heft 4.) By C. Keutner. Berlin, W. Ernst & Sohn, 1931. 27 pp., illus., diagrs., 11 x 7 in., paper, 4.20-r. m.——Gives the results of observations of flow phenomena over weirs in glass channels and of experiments to find equations for the flow which will be accurate in cases where the usual equations fail. Rehbock's formula is found correct for certain conditions; other formulas are developed for special cases.

Elements of Thermodynamics. By Ernest M. Fernald. N. Y., McGraw-

Hill Book Co., 1931. 329 pp., charts, diagrs., tables, 9 x 6 in., cloth. $3.50.——Professor Fernald's aim is to give the student an adequate, flexible technique for dealing quantitatively with various situations, and sufficient data for meeting the simpler ones; together with clear ideas of the limitations that universal laws impose upon engineering practise, and of the conditions that practise must meet before finally perfected. The properties, processes, and cycles of steam and perfect gases, compressed air, refrigeration, evaporation and flow through nozzles, etc., are discussed.

Practical Radio including Television. 4th edit. By J. A. Moyer and J. F. Wostrel. N. Y., McGraw-Hill Book Co., 1931. 410 pp., illus., diagrs., charts tables, 8 x 5 in., cloth, $2.50.——A popular exposition of the principles of radio and of the usual types of receiving apparatus. Advice on the selection and operation of receivers is given and also upon the construction and testing of some typical sets. This edition has a new chapter on television as well as numerous revisions and corrections.

Practical Marine Diesel Engineering. 2nd edit. By L. R. Ford. N. Y., Simmons Boardman Publ. Co., 1931. 758 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth. $7.00.——Discusses construction and operation from the point of view of the practical engineer. Theoretical principles are explained briefly, the construction of the various parts of engines and the accessory equipment described, and detail given for a large number of makes of engines. A major portion of the book is devoted to operation, such matters as repairs, tests, and lubrication being explained quite fully.

Berechnungsgrundlagen und Konstruktive Ausbildung von Einlaufspirale und Turbinensaugrohr bei Niederdruckanlagen. By H. Rohde. Berlin, J. Springer, 1931. 112 pp., illus., diagrs., charts, tables, 10 x 6 in., paper, 11 r. m.——The design and construction of these important elements of a power plant are both hydraulic and mechanical problems, and the present book is intended to throw light upon the structural and mechanical phases of the subject. The study is intended to assist in determining the most efficient forms, with due attention to both hydraulic and structural considerations.

Aerial and Marine Navigation Tables. By J. E. Gingrich. N. Y., McGraw-Hill Book Co., 1931. 63 pp., diagrs., tables, 11 x 7 in., leather, $2.50. ——The aim of the compiler of these tables has been to combine speed, facility in use, and simplicity with accuracy. A uniform plan in the solution of all sights has been adopted, and the volume is usable over a wide range and of handy size. The tables are rearrangement of those devised by Doctor Ogura of the Japanese Navy.

Electrical Engineering. By C. V. Christie. N. Y., McGraw-Hill Book Co., Inc., 1931. 662 pp., diagrs., charts, tables, 9 x 6 in., cloth, $5.00.——The fourth edition of this well-known text preserves the characteristics of former issues, but certain additions have been made, including an outline of the mathematical relations required for solving problems in a-c. theory, the design of a commutating-pole d-c. generator, a discussion of the problem of system stability, and a set of typical problems.

L'Emploi des Unités dans la Pratique des Calculs. By F. Bétrancourt. Paris, Dunod, 1931. 91 pp., tables, 9 x 6 in., paper, 16 frs.——A collection of the geometrical, mechanical, electrical, magnetic, and optical units of measurement, with definitions, formulas, etc., intended to aid calculators.

Experimental Radio Engineering. By J. H. Morecroft. N. Y., John Wiley & Sons, 1931. 345 pp., illus., diagrs., charts, tables, 10 x 6 in., cloth, $3.50.——A laboratory course in the principles of radio, listing fifty-one experiments and designed to bring out characteristics of component parts of receiving and transmitting apparatus; the introduction is upon laboratory apparatus.

Sags and Tensions in Overhead Lines. By C. G. Watson. London & N. Y., Isaac Pitman & Sons, 1931. 192 pp., diagrs., charts, tables, 9 x 6 in., cloth, $3.75.——Presenting simple accurate methods for determining these sags and tensions, and requiring no further mathematical knowledge than an ability to plot and read graphs, and perform simple arithmetical operations. All the cases ordinarily met in practise are discussed and explained. Tables and graphs of hyperbolic and catenarian functions and a table of tangents are given.

Vector Analysis. By L. R. Shorter. London & N. Y., Macmillan & Co., 1931. 356 pp., diagrs., 8 x 5 in., cloth, $2.75.——The extensive use of vector methods in modern text-books of physics makes it necessary for the student of mathematical physics to have a working knowledge of vector analysis. This brief text is intended to supply that need. It is suited also for use as an introduction to the subject for students of mathematics.

Seeing, A Partnership of Lighting and Vision. By M. Luckiesh and F. K. Moss. Baltimore, Williams & Wilkins Co., 1931. 241 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $5.——Seeing depends upon light and lighting as well as upon the visual sense; yet light and lighting have not yet received much consideration as a partner of the visual sense, the authors assert, although excellent scientific data pertaining to vision are available. The present book aims to remedy this lack, in part, by giving the results of extensive research work, covering some 20 years of effort to establish the scientific principles of seeing. A bibliography is included.

Foundations of Radio. By Rudolph L. Duncan. N. Y., John Wiley & Sons, Inc., 1931. 246 pp., illus., diagrs., tables, 8 x 6 in., cloth, $2.50.——An introductory text-book on electricity covering in non-mathematical language the fundamentals of interest to students of radio engineering.

Mitteilungen aus den Forschungsanstalten, GHH-Konzern, Bd. 1, Heft 5, pp. 101-122, May 1931. Berlin, V. D. I. Verlag. Illus., diagrs., charts, tables, 12 x 9 in., paper, 3 r. m.——The first article in this bulletin discusses the use of large diesel engines in electric power plants. Their advantages for peak-load service and as standbys are shown. The bulletin also reports on investigations of methods of drying wood and their effects upon its mechanical properties.

Nature of a Gas. By L. B. Loeb. N. Y., John Wiley & Sons, 1931. 153 pp., diagrs., charts, tables, 9 x 6 in., cloth, $2.50.——Students and engineers interested in the behavior of dielectrics as insulation will be grateful for this review of the nature and electric properties of a gas afforded by this monograph. The structure of the molecule is discussed, and its behavior under various temperature conditions considered. The monograph is the first of a series sponsored by the committee on electrical insulation of the Division of Engineering and Industrial Research, National Research Council.

Die Anwendung der Nomographie in der Mathematik. By H. Schwerdt. Berlin, J. Springer, 1931. 116 pp., charts, diagrs., tables, 10 x 6 in., cloth. 28 r. m.——This book contains 104 charts containing 236 nomographs of various mathematical formulas, which illustrate the possibilities of nomographic methods in mathematics. The text explains the charts and shows how they may be used. A brief bibliography is included.

International Critical Tables of Numerical Data, Physics, Chemistry and Technology. v. 7. By the National Research Council. N. Y. McGraw-Hill Book Co., 1930. 507 pp., 11 x 9 in., cloth $84.00 (7 v).——This is the final volume of the work in which the best values for an immense number of constants and numerical data of physics, chemistry, and engineering are recorded for the convenience of research workers. The values are based upon all recorded work previous to 1924, as in the "Annual Tables of Constants and Numerical Data." The values given in the present work have been chosen by competent authorities as the most satisfactory. References to original publications are included. Indispensable in research laboratories and libraries of science.

Onward Industry! By J. D. Mooney and A. C. Reiley. N. Y. & London, Harper & Brothers, 1931. 564 pp., 10 x 6 in., cloth, $6.00.——An endeavor to discover and define the principles of efficient organization, by studying principles used by great political, military, and ecclesiastical organizations of the past. A historical review of human experience with large organizations, accompanied by a study of present coordination and operation problems in modern industrial corporations.

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Selected Items From

Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Busbars

PROTECTION. Differential-Bus Protection Proves Its Merit, H. H. Cox. *Elec. World*, vol. 98, no. 1, July 4, 1931, p. 30, 2 figs. Inasmuch as station bus failures are always of serious nature it was realized by engineers of Department of Water and Power of city of Los Angeles that some form of bus protection was essential; original scheme of differential bus protection was proposed by author which involved connecting in parallel of as many current transformer secondaries as there were connections to bus in question.

Cables

INSULATION. Cable Insulation Thickness Can be Reduced, D. W. Roper. *Elec. World*, vol. 98, no. 1, July 4, 1931, pp. 27-29, 6 figs. Number of questions arose in connection with development of transmission system in Chicago region, such as maximum economical size for 132-kv. cable, feasibility of 220-kv. cable and economics of use of oil-filled cable for 60 kv. or lower voltages; some preliminary studies had indicated that most economical cable for given set of conditions would be determined by annual charges rather than by first cost, and this led to decision to extend investigations in progress so as to cover entire range of transmission voltages. Before Am. Inst. Elec. Engrs.

OIL-FILLED. The Theory of Oil-Filled Cable—I, G. B. Shanklin and F. H. Buller. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 416-420, 8 figs. Purpose of article is to round out general theory of high-tension oil-filled cable and describe additional development of important nature that have not yet been dealt with in technical press; article is sequent to recent A. I. E. E. paper by same authors "Characteristics of Oil-Filled Cable," two publications give fairly complete summary of latest oil-filled cable practise developed by General Electric Co.

Circuit Breakers

Influence de la forme de la tension de rupture sur le travail des disjoncteurs (Influence of Breaking Voltage Wave Form on Performance of Circuit Breakers), J. Kopeliowitch. *Association Suisse des Electriciens—Bul.*, vol. 22, no. 13, June 26, 1931, pp. 312-317, 8 figs. Comparative study of values obtained in cathode ray oscillographic research in 132-kv. lines of Ohio networks and in tests at high tension laboratory of Brown Boveri, Baden. Bibliography.

Clocks

ELECTRIC. Electric Clocks, F. Hope-Jones. Lond., N. A. G. Press, 1931, 261 pp., diagrs., 12 s. 6d. Combination historical and technical account of evolution of electric clock; starting with Alexander Bain's patent of 1840, author describes and criticizes efforts of successive inventors and illustrates steps that have led to highly accurate devices of today; numerous diagrams add to usefulness of book. Eng. Soc. Lib., N. Y.

Condensers

SYNCHRONOUS. Automatic Synchronous Condensers of the Washington Water Power Company, E. Baughn. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 421-424, 4 figs. Operate on 110-kv. lines; two machines, 7,500 kva. and 10,000 kva.; purpose to increase capacity and improve voltage regulation of lines; automatic control equipment; its functions and operation under normal and abnormal conditions.

Dielectrics

Dielectric Properties and Chemical Constitution, S. O. Morgan. *Bell Laboratories Rec.*, vol. 9, no. 11, July 1931, pp. 535-542, 9 figs. Atomic study.

Diesel-Electric

POWER PLANTS, AUTOMATIC. The Present Position of the Automatic Diesel-Electric Plant, E. J. Kates. *Mech. Eng.*, vol. 53, no. 7, July 1931, pp. 525-528, 2 figs.; see also *Power*, vol. 73, no. 25, June 23, 1931, pp. 990-993, 4 figs. Paper before Am. Soc. Mech. Engrs., previously indexed from Advance Paper, for mtg. June 23-26, 1931.

POWER PLANTS—COSTS. Report on Oil Engine Power Cost for 1930. *Am. Soc. Mech. Engrs.,—Advance Paper*, for mtg. June 23-26, 1931, 5 pp. Information covering 81 oil-engine generating plants, containing 253 engines, totaling 146,865 rated b.hp.

Electrical Engineering

The High Tension Conference. *Engineering*, vol. 131, no. 3413, June 12, 1931, p. 773, 2 figs. Sixth session of International Conference on Large High Tension Systems will take place from June 18 to 27, in Paris; reports on following subjects will be presented: study of behavior of transformer and other insulating oils; design and tests of oil circuit-breakers; parallel operation of power plants; investigation of surges; study of reactive power; grounding of neutrals; high-tension insulators and high-tension underground cables.

BIBLIOGRAPHY. A Bibliography of Bibliographies in Electrical Engineering 1918-1929, edited by K. Maynard. Providence, R. I., Special Libraries Assn., 1931, 156 pp., $1.50. List of references, without annotations, from 68 serials, arranged alphabetical by subject headings, giving number of items.

Electric Discharge

AIR. Berechnung der Anfangspannung zwischen kantigen Elektroden in Luft (Calculation of Initial Voltage Between Edged Electrodes in Air), W. Schilling. *Arbeiten aus dem Institut fuer elektrische Messkunde und Hochspannungstechnik der Technischen Hochschulp Braunschweig*, vol. 1, 1931, pp. 1-12, 15 figs. Field distribution; general discharge conditions and their application in calculation for various positions and edge angles.

MERCURY VAPOR. Electrical Discharges in Mercury Vapour and Their Control, H. de B. Knight. *Rugby Eng. Soc.—Proc.*, vol. 25, pt. 1, 1930-1931, pp. 23-62, 7 figs. General features which are of importance in connection with prevention of backfiring in mercury-arc power rectifiers, and operation of thyratron. Bibliography.

Electric Drive

BLOOMING MILLS. Algoma Steel Corporation Modernizes Rail Mill, A. F. Kenyon. *Blast Furnace and Steel Plant*, vol. 19, no. 6, June 1931, pp. 832-835, 4 figs. Previously indexed from Elec. News, Apr. 1, 1931.

ROLLING MILLS. The Twin-Motor Drive for Main Rolls, R. H. Wright and H. E. Stokes. *Rolling Mill Jl.*, vol. 5, no. 6, June 1931, pp. 403-406, 4 figs. Development and advantages of this type of drive. Before Assn. Iron and Steel Elec. Engrs.

Electric Light

General and Supplementary Lighting Components, M. Luckiesh. *Elec. World*, vol. 98, no. 2, July 11, 1931, p. 74. Notwithstanding many factors involved in lighting for seeing, means available to lighting specialist for improving seeing are relatively few compared with those available to seeing specialist; among these, quantity of light, or foot-candles, is by far most effective for universal application.

ULTRA-VIOLET. Diffusely Transmitting Media for Ultraviolet Radiation, M. Luckiesh. *Elec. World*, vol. 97, no. 26, June 27, 1931, pp. 1232-1233. Results of measurements of diffuse transmission for light and for ultraviolet radiation; measurements of ultra-violet transmission were made by use of blue fluorescing attachment for Macbeth illuminometer, using sunlight "Mazda" lamp (S-1) as source of ultra-violet radiation.

Electric Manufacturing Plants

TIME-STUDY. Use of Formulas and Charts for Rate-Setting, G. J. Stegemerten. *Factory and Indus. Mgmt.*, vol. 82, no. 1, July 1931, pp. 52-56, 4 figs. Compilation of set of time tables by Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

Electric Power

Electrical Home Service, E. E. Hoadley. *Elec. Rev.*, vol. 108, no. 2795, June 19, 1931, p. 1028. Practical comment and experience of consumers point of view on cost of service; flat irons; heating; cooking; water heating; future; all-electric homes. Before Inc. Mun. Elec. Assn.

Electrochemistry

A Method for Determining the Change in Transference Number of a Salt with Change in Concentration; a Modification of the Moving Boundary Method, E. R. Smith. *U. S. Bur. Standards—Jl. Research*, vol. 6, no. 6, June 1931, pp. 917-926, 5 figs. Junctions between solutions of same salt at different concentrations are formed and volumes through which junctions move during passage of known amounts of electricity are measured; method was tested for solutions of lithium, sodium, and potassium chloride.

Electrolytic Oxygen

MANUFACTURE. Markets for Gases Electrolyzed with Off-Peak Power, P. McMichael. *Elec. World*, vol. 97, no. 25, June 20, 1931, pp. 1182-1185, 3 figs. Outlets for oxygen well established; new hydrogen markets make electrolysis of water economically feasible; cell plant in conjunction with generating station to utilize off-peak power.

Engineering

INDUSTRIAL RELATIONSHIP. Coordinating Engineering with other Company Activities, L. E. Jermy. *Machine Design*, vol. 3, no. 6, June 1931, pp. 27-29. Procedure followed by eight companies using committees and conferences to broaden scope of activities of engineering departments.

INFLUENCE ON CIVILIZATION. Technology and Material Progress, W. R. Whitney. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 403-405. Paper before Am. Philosophical Soc., previously indexed from Science, May 8, 1931.

Engineering Education

Education for the Engineering Industry. *Nature (Lond.)*, vol. 127, no. 3215, June 13, 1931, pp. 881-886. Review of report of Committee appointed by President of Board of Education to inquire into technical education for engineering industry.

Engineering Ethics

A New Code of Ethics Needed. *Eng. News-Rec.*, vol. 106, no. 26, June 25, 1931, pp. 1036-1037. Editorial on necessity of revising engineering code of ethics, in such way that advertising and competition be recognized and proper limits set upon them; fees and compensation may also need to come up for consideration.

Furnaces

ANNEALING. The Annealing of Metal Strip in the Continuously-operated Electric Furnace. *Metal Industry (Lond.)*, vol. 38, no. 26, June 26, 1931, pp. 641-643, 4 figs. In addition to electrically heated muffle furnaces, specially designed types of furnace have been put on market, and in particular, so-called "pull-through" furnaces; as against short type, horizontal pull-through furnaces, where wages constitute higher portion of total operating costs, continuously working strip annealing plants with pickling trough, washing machine and drying furnace, are capable of meeting most exacting demands.

ENAMELING. Economic Operation of Electric Enameling Furnace, A. M. Young. *Elec. World*, vol. 97, no. 25, June 20, 1931, pp. 1168-1170, 1 fig. Difference of nearly 13 per cent in net rate for furnace energy from one month to next was disclosed by recent study of electric enameling operation in plant of Chicago Hardware Foundry Co. at North Chicago, Ill.; difference was caused by varying incidences of furnace demand on total plant demand; charts showing effects of furnace load on customer's demand.

INDUCTION. Tonnage Melting by Coreless Induction—IV, E. F. Northrup. *Fuels and*

Furnaces, vol. 9, no. 7, July 1931, pp. 833-838, 3 figs. Stirring of metal and its control and power density of large and small furnaces.

REFRACTORY MATERIALS. Refractory Materials for Electric Furnaces—III, A. B. Searle. *Metal Industry (Lond.)*, vol. 38, no. 23, June 5, 1931, pp. 569-571. Nickel and its alloys, including nickel-chromium alloys and nickel-silver; fact that nickel has melting point of 1,452 deg. cent. makes it necessary to employ, as materials for lining furnaces, those of greater refractoriness than ones used for copper and lead and their alloys.

Refractory Materials for the Induction Furnace, J. H. Chesters and W. J. Rees. *Iron and Steel Industry*, vol. 4, no. 10, July 1931, pp. 347-348. Paper before Iron and Steel Inst., previously indexed from Engineering June 12 and 26, 1931.

STEEL MAKING. Use of Sillimanite as Material for Furnace Covers, M. F. Sommer. *Blast Furnace and Steel Plant*, vol. 19, no. 6, June 1931, pp. 861-864, 1 fig. Tests indicate that sillimanite is much more expensive than silica, and durability under most favorable conditions is about same; no evidence was forthcoming which would lead to belief that through improvements in process of manufacture of either sillimanite bricks or of cover rammed up with sillimanite clay, increase in durability might be attained which would even approximately correspond to price ratio.

Generators

PARALLEL OPERATION. Re-exciting Loaded Alternators in Parallel with Others, D. D. Higgins and E. Wild. *Power*, vol. 73, no. 26, June 30, 1931, pp. 1041-1042. In order to establish reasonably safe operating procedure for such emergencies and one that will reestablish normal conditions just as soon as possible, authors have collected data on experiences and statements for various sources and have determined, by tests, behavior of large units under these abnormal conditions. Before Am. Inst. Elec. Engrs.

REGULATION. Generator Voltage Regulated by Corona Tube, H. W. Dodge and C. H. Willis. *Elec. World*, vol. 98, no. 1, July 4, 1931, pp. 25-26, 4 figs. Characteristics of corona discharge tube make its critical voltage suitable for constant element in regulator; fact that it regulates to constant peak voltage rather than constant effective voltage is not serious disadvantage, for variation of wave form with load is not appreciable and there will therefore be constant form factor. Before Am. Inst. Elec. Engrs.

SYNCHRONIZING. Correct Generator Synchronizing Insured by Auxiliary Control, J. Auchincloss. *Elec. World*, vol. 97, no. 26, June 27, 1931, p. 1214, 1 fig. Auxiliary switches on generator breaker control prevent faulty closing; wiring diagram.

Limitations in Synchronizing, H. S. Baker. *Hydro-Elec. Power Commission of Ont.—Bul.*, vol. 18, no. 6, June 1931, pp. 208-220, 28 figs. In hand synchronizing, limitations of speed difference and phase differences at moment of closure are learned in very crude manner; with automatic synchronizing it is possible to set above speed difference and phase difference limitations to known values; object of paper is to determine in rational manner values of these limitations in order to be able to make necessary adjustments to automatic synchronizing devices.

Hoover Dam

CONSTRUCTION POWER LINE. Rushing the Power Line to Hoover Dam Site, R. H. Halpenny. *Eng. News-Rec.*, vol. 106, no. 26, June 25, 1931, pp. 1054-1057, 5 figs. Rugged desert country crossed in 225 days by 225 mi. 132 kv. transmission line from San Bernardino, Cal. to serve Hoover Dam construction activities digging 7 ft. holes for tower bases; four erectors and two helpers fabricated each 52-ft. tower piece by piece from ground up; stringing three conductors at same time.

Hydroelectric Plants

DROUGHT EFFECT. Drought of 1930 Shifts Power Load to Steam Stations, G. T. Bogard. *Southern Power Jl.*, vol. 49, no. 6, June 1931, pp. 34-38, 4 figs. Following three articles outline power generation difficulties experienced in south during 1930: Unparalleled Water Deficiency Seriously Affected Even Steam Stations, G. T. Bogard; High Steam Electric Capacity Solves Drouth Problems in West Virginia, G. Ellis; Excellent Maintenance Stood Virginia System in Good Stead, M. Cary; principal generating stations as of January 1, 1931, Kentucky Utilities Company and Appalachian Electric Power Company; records of river flow and hydro power output for 1928, 1929 and 1930.

MAINTENANCE AND REPAIR. Organizing for Plant Operation and Maintenance, A. S. Robertson. *Hydro-Elec. Power Commission of Ontario—Bul.*, vol. 18, no. 6, June 1931, pp. 190-200, 5 figs. Value of service shop; organization chart and proposed maintenance schedule and actual record in days for Queenston generating station; duties of operating staff; preparing maintenance schedules; reducing time and costs; example of detailed job for rewinding a large generator; assembly of several individual job schedule sheets covering major repair on large unit.

NEW BRUNSWICK. The Economics of Power Plant Design, H. G. Acres. *Contract Rec.*, vol. 45, no. 24, June 17, 1931, pp. 731-734, 8 figs. Brief description of plant, for Edmundston, N. B., with 1,050-hp., high-speed, propeller-type, vertical turbine, direct-connected to 1,000-kva., 3-phase, 60-cycle, 2,300-volt, 240-r. p. m. generator, with direct-connected exciter and Kingsburgh thrust-bearing.

PUMPED STORAGE. High-Head Pumped-Storage Hydro-Electric Plant. *Engineering*, vol. 132, no. 3417, July 10, 1931, p. 61, 1 fig. New Plant at Sillre, town on River Indal, 220 mi. north of Stockholm; scheme is to employ power from existing plants, which is now suffered to escape in slack periods, to generate current which is to be transmitted to plant at Sillre, there to pump water up into storage reservoir.

Insulators

MANUFACTURE. The Manufacture of Porcelain Insulators. *Engineer*, vol. 151, no. 3935, June 12, 1931, pp. 658-659, 5 figs. Plants of Bullers, Ltd., at Milton and Tipton, England; manufacturing process and equipment; research work carried out by Company; every type of insulator used in electrical industry for telegraph and telephone work and for power work is made in Company's factories, including cap and pin-type insulator strings used for 132-kv. grid lines.

Lighting

COLOR. Work-World Environments, M. Luckiesh. *Mech. Eng.*, vol. 53, no. 7, July 1931, pp. 514-518. Light and color fundamentally desirable and powerful influences upon happiness; color schemes for factory interiors and machinery; economic value of pleasant environments for workers.

INDUSTRIAL. Good Lighting is a Good Investment, H. Chase. *Iron Age*, vol. 128, no. 2, July 9, 1931, pp. 84-87, 3 figs. Uniform illumination without glare or deep shadows is unquestioned aid in economical production work; examples show how properly designed system may result in enough saving to pay for equipment in less than year.

MOTOR BUS. Lighting Motor Buses and Coaches. *Ry. Gaz.*, vol. 55, no. 1, July 3, 1931, pp. 19-20, 4 figs. Details of dynamo designed to give 12 volts, 25 amp. from 1,500 to 4,000 r. p. m.; drivers switchboard; lighting controls for switchboard and interior lighting.

SHIP. Pivoted Ship Sidelight. *Engineering*, vol. 132, no. 3416, July 3, 1931, p. 28, 3 figs. New light introduced by J. Stone and Co., Deptford; sidelight is called stirrup light, as control is entirely effected by single stirrup-shaped handle.

STREET. Street Lighting and Traffic Accidents, K. M. Reid. *Elec. World*, vol. 97, no. 25, June 20, 1931, pp. 1186-1188, 3 figs. Analysis of Police department records of Cleveland, showed that traffic accidents in winter dusk exceeded midsummer's frequency; what good lighting system has accomplished; relation of lighting to fatal traffic accidents; fatalities on State roads in relation to lighting; Indiana highway fatalities. Before Am. Soc. Mun. Engrs.

UNITS. The Waidner-Burgess Standard of Light, H. T. Wensel, W. F. Roeser, L. E. Barbrow and F. R. Caldwell. *U. S. Bur. Standards—Jl. Research*, vol. 6, no. 6, June 1931, pp. 1103-1117, 4 figs. partly on supp. plate. Source of light sufficiently reproducible to serve as fundamental photometric reference standard has been obtained by carrying out in original suggestion of Waidner and Burgess to immerse hollow inclosure in bath of molten platinum and to make observation during period of freezing.

Lamps

Characteristics of Electric Lamps as Modified by Modern Methods of Manufacture, L. E. Buckell. *Machy. Market*, no. 1599, June 26, 1931, pp. 23-24. Early developments; introduction of metal filaments; gas-filled lamps; standardization; manufacturing methods; effects of small variations; uniformity of life; spiral filaments. Before Assn. Supervising Elec. Engrs.

Measuring Instruments

New Developments in Electrical Measuring and Auxiliary Testing Devices. *Nat. Elec. Light Assn.—Pub.*, no. 128, June 1931, 48 pp., 148 figs. Information concerning such devices and improvements which have been made available during year.

Meters

Direct Current Meters, S. B. Warder. *Elecn.*, vol. 106, no. 2769, June 26, 1931, pp. 941-942, 4 figs. Characteristics of ampere-hour and watt-hour meters.

SPECIFICATIONS. Summary of Public Utility Commission Rules and Regulations for Electricity Meters. *Nat. Elec. Light Assn.—Pub.*, no. 132, May 1931, 20 pp.

WATT-HOUR. Watt-Hour Meters, E. Fawssett. *Elec. Rev.*, vol. 108, no. 2795, June 19, 1931, pp. 1043-1044. Latest induction watt-hour meters are compared with those of few years ago, while there is no outstanding change to record, there has been distinct progress in detail and in performance.

Les compteurs Electriques a mercure (Mercury Watt Hour Meters), V. Neveux. *Industrie Electrique*, vol. 40, no. 935, June 10, 1931, pp. 253-261, 13 figs. Meters using mercury as low-friction material for pivoting; type of Ferranti Co., Chamberlain, Hookham, Compagnie pour la fabrication des compteurs, and Sangamo Electric Co.; applications.

Summation Meters and Some New Applications—1, C. W. Olliver. *Power Engr.*, vol. 26, no. 304, July 1931, pp. 270-273, 5 figs. Review of some modern summation equipment, with particular reference to their application to power station and other mechanical requirements.

Motor-Generators

Sur la régulation directe et les difficultés qu'entraine son etude (Direct Regulation and Difficulties in Its Analysis), Barbillion. *Revue de L'Industrie Minerale*, no. 250, May 15, 1931, pp. 171-185, 13 figs. In more general previous study (see Engineering Index 1930, p. 624), it was assumed that proportionality existed between terminal voltage and variations in angular speed; in present article, application in cases of temporary disturbances is mathematically analyzed and some new approximately exact methods of calculation are given.

Motor Trucks

ELECTRIC. Electric Trucks. *Nat. Elec. Light Assn.—Report*, no. 138, June 1931, 12 pp., 10 figs. Degree of electric truck use by electric utilities; application to transportation work; successful truck designs and battery combinations; data and opinions gathered from operating companies.

Motors

BRAKING. Brakes for Motors and Their Loads, H. M. French. *Power*, vol. 73, no. 26, June 30, 1931, pp. 1024-1026, 5 figs. Large amount of data available on starting motors and running them to suit particular application; lack of braking information; means of retarding, stopping and holding motors under various conditions of operation.

INDUCTION—DESIGN. Theorie van den dubbel gekoppelden lek, in het bijzonder bij draaistroom-kortsluitankermotoren (Theory of Double Coupled Leak with Special Reference to Three-Phase Squirrel Cage Induction Motors), M. Van Der Veen. *Polytechnisch Weekblad*, vol. 25, nos. 20 and 21, May 14, 1931, pp. 313-316, and May 21, pp. 329-334, 15 figs. Theoretical mathematical analysis. Bibliography.

LAMINATIONS. Production of Motor Laminations, R. L. Payne. *Metal Stampings*, vol. 4, no. 6, June 1931, pp. 481-486, 9 figs. Four different methods of preparing silicon steel in sheet form for production of motor laminations and equipment used for their production; scrap economy in ultimate production of laminations lies in method of preparing sheets.

Paper Mills

POWER FACTOR. Correcting Power Factor While Grinding Wood Pulp, W. P. Lyman. *Elec. World*, vol. 97, no. 25, June 20, 1931, p. 1189, 1 fig. By applying synchronous machines to motorization of dual-drive pulper equipment, Bogalusa Paper Co. of Bogalusa, La., was able to take advantage of power-factor clauses in purchased energy contracts and secure satisfactory operating performance.

Permalloy

Researches on the Rotation of Permalloy and Soft Iron by Magnetization and the Nature of the the Elementary Magnet, S. J. Barnett. *Am. Academy Arts and Sciences—Proc.*, vol. 66, no. 8, June 1931, 348 pp., 46 figs.

Photoelectric Cells

Photo Cells and Thyratrons, L. J. Davies. *Elecn.*, vol. 106, no. 2769, June 26, 1931, pp. 936-938, 8 figs. Growing importance of vacuum devices; elements of cell; properties of thyratrons.

Power Factor

An Elementary Discussion of Power Factor, J. Leech-Porter. *Can. Min. Jl.*, vol. 52, no. 23, June 1931, pp. 584-587, 3 figs. Preliminary contribution to question of power factor correction; principles of power factor, which are not very clear to men outside those who have specialized in electrical engineering, in simple and direct way.

Power Industry

Public Interest Demands Utility Merchandising. *Elec. World*, vol. 97, no. 25, June 20, 1931, pp. 1180-1181, 4 figs. Oregon utilities justify merchandising on grounds that consumers are entitled to maximum usage at minimum rates and furnish evidence proving that only through their activities has been made possible; graphs showing average annual use of electricity per domestic customers, average rate per domestic kw-hr., average annual kw-hr. use per domestic customer and decrease in average rate per domestic kw-hr.

Power Plants

STEAM-ELECTRIC. Foreign Developments. *Nat. Elec. Light Assn.—Pub.*, no. 131, May 1931, 38 pp., 53 figs. In general, trend of power-plant development is toward higher pressures and temperatures; American viewpoint of European situation is presented in composite statement of several engineers who attended World Power Conference, Berlin; peak-load problem; tendencies of modern German steam generation; trend of developments in central stations and equipments in England; Golpa-Zschornewitz plant of Elektrowerke Aktiengesellschaft; tests on Ruths accumulator plant in Charlottenburg power station. Bibliography.

Power Supply

NEW YORK CITY. The Power Behind New York—II. *Power Plant Eng.*, vol. 35, no. 13, July 1, 1931, pp. 702-707, 7 figs. Features of system operation; analysis and application of load curves; factors affecting system operation; determination of incremental rates; frequency and voltage regulation.

RURAL. A Report on Farm Electrification Research. *Committee on Relation Electricity to Agriculture—Bul.*, vol. 6, no. 1, June 1931, 79 pp. Progress of investigations of different types which have been conducted; analysis of agricultural development; major economic and production problems in which electricity may be involved; plan and program for continuation of research activities; investigations under way and proposed; work done and need for further investigations in that particular field.

Pumping

PETROLEUM PIPE LINES. Electricity in the Transportation of Oil, G. R. Prout. *Oil and Gas Jl.*, vol. 30, no. 2 to 4, June 4, 1931, (supp.) pp. T99 and T101, 7 figs. Review of reasons for tendency towards use of electric motors for pipe line pumping; gathering line and trunk line work; advantages of automatic operation; Diesel electric pumping stations; 160,000 hp. in motor capacity is now installed in oil pipe line stations in central and southwest United States.

Remote Control for Electric Stations, L. G. E. Bignell. *Oil and Gas Jl.* vol. 30, no. 2 to 4, June 4, 1931, (supp.) pp. T49-T50, 1 fig. Outline of control system devised by Westinghouse Electric & Manufacturing Co.; one station equipped in Oklahoma.

Motor Heat Controlled in New Sinclair Pump Station, J. C. Albright. *Oil Weekly*, vol. 62, no. 2, June 26, 1931, pp. 25-26, 4 figs. Oklahoma City-Coffeyville line booster stations are all alike in design and equipment, with two Byron Jackson three-stage oil line pumps, capacity 60,000 bbl. oil daily at 3,550 r. p. m.; each pump connected by Fast's self-aligning coupling to General Electric Type FT-559-AY form EL2,200-volt three-phase 60 cycle induction motor, delivering 500 hp.; normal operating temperature 104 deg. fahr.; provisions for air circulation and hot air disposal.

Radio

AIRPLANES. Some Considerations Affecting Design of Aircraft Wireless Equipment, J. A. McDonald. *Roy. Air Force Quarterly*, vol. 2, no. 2, Apr. 1931, pp. 258-269, 4 figs. on supp. plates. Reliability and type of apparatus for signaling between aircraft in flight and between aircraft and ground stations.

Temperature Rating of Engine Driven Aircraft Radio Generators, C. B. Mirick and H. Wilkie. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1175-1181, 11 figs. Previously described methods of temperature measurement and computation are applied to engine driven aircraft radio generators in flight; observed and computed heating curves are shown from which emission constant for this type of machine has been derived.

AMPLIFIERS. High Audio Power From Relatively Small Tubes, L. E. Barton. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1131-1149, 11 figs. Method by which audio outputs 5 to 10 times usual output of tube of given size may be obtained with same plate voltage, lower average plate dissipation, and no serious effects on tube; results are obtained by using in such manner that advantage is taken of essential features of class "B" amplifier.

Note on Radio Frequency Transformer Coupled Circuit Theory, J. R. Nelson. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1233-1241, 4 figs. Equations considering effects of output and distributed capacities and primary resistance are developed for radio-frequency transformer-coupled amplifiers using either tuned or untuned primary; these equations are transformed to such form that they may be compared with well-known equations derived for untuned primary neglecting output and distributed capacities; equations for untuned primary are verified experimentally.

AMPLIFIERS—COUPLING. Maximum Amplification in Capacity-coupled Circuits, W. van B. Roberts. *Electronics*, vol. 3, no. 1, July 1931, pp. 20 and 42, 2 figs. In analysis given only two approximations are introduced and neither of these is believed to be capable of making appreciable difference in any ordinary circuit.

ANTENNAS, SHORT WAVE. Theoretical and Practical Aspects of Directional Transmitting System, E. J. Sterba. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1184-1215, 19 figs. More important principles involved in development of directional transmitting antennas at present employed in Bell system short-wave facilities; theoretical performance of directive arrays is presented by means of various curves which have been obtained by integrations based upon Poynting's theorem; various practical problems in development including antenna tuning procedure, transmission line adjustments, and sleet melting facilities.

CIRCUITS—TUNING. Tuning by Permeability Variation, R. H. Langley. *Electronics*, vol. 3, no. 1, July 1931, pp. 8-10, 2 figs. Results of W. J. Polydorff studies and experiments by which is attained that variable air condensers are replaced by iron cores inserted gradually into radio frequency transformers; curve showing amplification and selectivity of screen-grid tube with iron core transformer; simple analysis is given.

COILS—DESIGN. Supplementary Note to the "Study of the High-Frequency Resistance of Single-Layer Coils," A. J. Palermo and F. W. Grover. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1278-1280. Since publication of above paper in Dec. 1930 number, indexed in Engineering Index 1930, p. 1415, attention of authors has been called to two articles on a-c. resistance of solenoidal coils by S. Butterworth, which were overlooked in preparation of paper; tabulated results show that for coils measured, Butterworth's formula 30 gives best agreement with measured values in all except few cases.

DETECTORS. High Level Automatic or Self-Bias Detection, J. R. Nelson. *Electronics*, vol. 3, no. 1, July 1931, pp. 14-15, 3 figs. Circuit used for experimental determination of self-bias detection characteristics; calculation of rectified output; dynamic characteristics of typical self-bias detector; rectification curves of 27 detectors.

FREQUENCY—MEASUREMENT. Frequency Measurement in the British Post Office, F. E. Nancarrow. *Post Office Elec. Engrs.—Jl.*, vol. 24, pt. 2, July 1931, pp. 155-159, 4 figs. In radio department of British Post Office, all frequencies are measured by reference to harmonic frequencies of tuning-fork maintained in Radio laboratories at Dollis Hill, Lond.; this fork can be regarded as Post Office standard of frequency; fork and temperature control; pressure effect.

MEASURING INSTRUMENTS. Thermojunctions at High Radio-frequencies, F. M. Colebrook. *Experimental Wireless*, vol. 8, no. 94, July 1931, pp. 356-361, 5 figs. Object of investigation was to obtain information about frequency variation of thermo-junction milliammeters; tube rectifier milliammeters was specially designed for purpose of inter-comparison of thermo-junctions investigated and vacuum tube instrument.

OSCILLATORS, PIEZOELECTRIC. Performance of Piezo-Oscillators and the Influence of the Decrement of Quartz on the Frequency Oscillations, M. Boella. *Inst. Radio Eng. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1252-1273, 21 figs. Performance of piezo oscillators of usual Pierce circuits is treated, on basis of resonance curves of quartz and with help of vector diagrams; influence of decrement of quartz resonator on oscillation frequency is examined; study has led to arrangement which permits quartz to oscillate in proximity to its frequency of resonance and to reduce thereby influence of decrement on frequency to about 1/10 of that usually found.

TRANSMISSION. Notes on Radio Transmission, C. N. Anderson. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1150-1165, 16 figs. Considerable data on radio transmission have been obtained past few years in connection with establishment and operation of various radio-telephone services by Bell System; purpose of notes is to present certain aspects of some of these data which may be of interest in development of general physical picture of radio transmission and in indicating effects of disturbances accompanying storms in earth's magnetic field.

TUNING. Tuning by Permeability Variation, R. H. Langley. *Electronics*, vol. 3, no. 1, July 1931, pp. 8-10, 2 figs. Results of W. J. Polydorff studies and experiments by which is attained that variable air condensers are replaced by iron cores inserted gradually into radio frequency transformers; curve showing amplification and selectivity of screen-grid tube with iron core transformer; simple analysis is given.

Railroad

AUTOMATIC BLOCK SIGNALS. Committee VIII—Alternating Current Automatic Block Signaling, W. F. Follett. *Am. Ry. Assn.—Proc.* (*Signal Sec.*), vol. 28, no. 3, June 1931, pp. 487-490. Specifications covering made ground apparatus for lighting arresters; and oil-immersed self-cooled line transformers.

Committee IV—Direct Current Automatic Block Signaling, E. N. Fox. *Am. Ry. Assn.—Proc.* (*Signal Sec.*), vol. 28, no. 3, June 1931, pp. 490-500. Condensation of moisture and formation of frost on signal apparatus; direct current track circuit test record; plug type rail bonds and track circuit connectors; rail bond; plug type; track circuit connector; relay contact post designation plate.

INTERLOCKING SIGNALS. Committee II—Interlocking. *Am. Ry. Assn.—Proc.* (*Signal Sec.*), vol. 28, no. 3, June 1931, pp. 501-506. Car retarder system; electric motor switch operating mechanism; centralized traffic control system; centralized traffic control machine; electric look; time release; interlocking lever circuit controller.

ELECTRIC CONTROL SWITCHES. The Sheremeteff Electro-Gravity Point Mechanism. *Ry. Engr.*, vol. 52, no. 617, June 1931, pp. 214-215, 5 figs. partly on p. 224. Details of system in use on London and North Eastern, whereby wheels of passing train provide necessary energy for operating pair of points; wiring diagram of operating mechanism.

ITALY. The Bologna-Florence Direttissima Railway and the Great Apennin Tunnel. *Engineer*, vol. 151, no. 3936, June 19, 1931, pp. 676-680, 12 figs. Route has length of 97 km. with double track; maximum gradient is 1 in 83; stations are capable of accommodating trains 500 m. long; longest tunnels are Great Apennine, 18,510 m., Monte Adone, 7,135 m., and Pian di Setta, 3,045 m. long; longest viaduct is at Vado, carried on 14 arches, each of 20 m. span; ventilation and methods of driving tunnels; line will be electrified on three-phase system at 3,700 volts and 16⅔ cycles, current being supplied from converter station at San Viola, Bologna.

ELECTRIFICATION — LACKAWANNA. Lackawanna Railroad. *N. Y. Railroad Club—Off. Proc.*, vol. 41, no. 7, May 1931, pp. 9625-9660, 18 figs. Symposium of papers: Lackawanna Suburban Electrification in New Jersey, G. J. Ray; High Spots of Electrification on Lackawanna R. R., E. L. Moreland; Informative and Interesting Description of Sub-Stations and Construction of Catenary System, J. S. Thorp; My Experience with Commuters, J. J. Pierce; Multiple-Unit Cars, Three-Power Locomotives and Training of Employes for Delaware, Lackawanna and Western Railroad Electrification, E. E. Root.

SIGNALS AND SIGNALING. Committee X—Signaling Practice, W. M. Post. *Am.*

Ry. Assn.—Proc. (*Signal Sec.*), vol. 28, no. 8, June 1931, pp. 455-479. Automatic train control; locomotive cab signals; requisites for centralized traffic control system, automatic block signal system and interlocking system.

Rectifiers

JET WAVE. The Jet-Wave Rectifier; An Account of Its Constructional Development During the Years 1919-1929, no. 24, edited by J. Hartmann, Copenhagen, Danmarks Naturvidenskabelige Samfund I Kommission Hos G. E. C. Gad. *Vimmelskaftet* 32, 1931, 300 pp., figs., diagrs., 30 kr. General principles; jet; jet-wave; hydrodynamic circuit; magnet; auxiliary electrode; main electrode I; main electrode II; complete rectifier; rectifier plant; this research work has undertaken with view of developing high power rectifiers on basis of jet-wave principle; history of this principle and of its development before and after 1919 is given in appendix.

MERCURY-ARC. An Automatically-Controlled Rectifier on the London Underground Railway. *Engineer*, vol. 152, no. 3938, July 3, 1931, pp. 19-20, 7 figs. Rectifier installed by B. T. H. Co. in Hendon substation of London Electric Railway Co.; among special features, are: indestructible construction of anodes and anode enclosures, six-phase excitation, and accurate temperature control.

Mercury-arc Rectifiers, H. Rissik. *Elec. Rev.*, vol. 108, no. 2794, June 12, 1931, pp. 991-92, 6 figs. Recent developments in their application to heavy-duty work.

Refrigeration

Electric Refrigerators and Electric Refrigeration, C. H. Roe. *Ice and Refrig.*, vol. 80, no. 6, June 1931, pp. 473-474. Advent of electric refrigerators stimulated refrigeration industry; importance of information on performance and costs; standardization of household refrigerators. Before Nat. Electric Light Assn.

Resistance

GROUND. Guessing Ground Resistances Is a Risky Procedure, S. W. Borden. *Elec. World*, vol. 97, no. 25, June 20, 1931, p. 1172. Tests were made recently on steel tower line located where earth for some depth consists of sand and gravel; four tower legs, which form 15 ft. square, are buried directly in ground and each tower carries two three-phase, 66-kv. circuits; results of various measurements are given.

Substations

AUTOMATIC. Automatic Switching Equipment for Motor-generator Sets at the Campbell Works of the Youngstown Sheet & Tube Company, C. M. Myers and J. H. Graft. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 431-435, 7 figs. Central substation was erected in 1926; in selection of switching equipment for motor-generator sets; location for equipment; attendants available; importance of maintaining continuous power on all feeders; simplicity of equipment; justifiable cost are to be considered.

DESIGN. Meeting Space Limitations in Urban Substations. *Elec. World*, vol. 97, no. 26, June 27, 1931, pp. 1224-1229, 18 figs. Various basic principles of design affecting space allocation and number of detailed features of economical treatment in equipment placement by power companies in eastern New England are cited; table showing clearances according to operating voltages; used by Boston Edison Co. station engineering department.

Substation Expansion Typifies Economy of Designing for Future Requirements, A. Shipek *Elec. West*, vol. 66, no. 7, June 1, 1931, pp. 610-611, 3 figs. Design features of terminal substations of Puget Sound Power and Light Co. Seattle, Wash.

Switchboards

SUPERVISORY CONTROL. Miniature Supervisory Control Gives Creditable Performance, R. M. Stanley, *Elec. World*, vol. 98, no. 1, July 4, 1931, pp. 22-25, 2 figs. With miniature switchboard operator is at all times closer to indicating instruments, control switches, etc., and can give better and closer supervision to operation of equipment, resulting in better voltage control, frequency control and division of load among generating units; there is great saving in time during regular operation and human error is largely eliminated. Before Am. Inst. Elec. Engrs.

Switchgear

Switchgear, H. Astbury. *Engineer*, vol. 151, no. 3936, June 19, 1931, p. 680. Discussion on rupturing capacity of extra-high-tension and low-tension switchgear to be installed on customers' premises. Before Instn. Elec. Engrs.

Telephone

AUTOMATIC. Common Control System, R. Taylor and C. E. Beale. *Post Office Elec. Engrs.—Jl.*, vol. 24, pt. 2, July 1931, pp. 125-131, 6 figs. In Common Control System, transitory functions are performed by detached groups of relays, each group being arranged to control number of switches; to switches themselves are fitted only relays that are required for full duration of call, plus one relay that serves to link up with common control group during setting up of call.

CONDENSERS. Telephone Condensers, R. E. W. Maddison and S. Chapman. *Elec. Communication*, vol. 10, no. 1, July 1931, pp. 39-44, 3 figs. Production and properties of paper condensers, no theories of dielectrics are included; electrodes; paper; materials; impregnating medium; process of manufacture; "Mansbridge" Condensers; electric properties; capacity; power losses; life tests.

RELAYS. Characteristics of Strowger Relays, K. W. Graybill. *Telephone Engr.*, vol. 35, no. 6, June 1931, pp. 30-31, 4 figs. Various methods used to determine mechanical adjustment values of horizontal relays together with reference tables governing these values.

TRANSOCEANIC. International Telephony, H. S. Osborne. *West. Soc. Engrs.—Jl.*, vol. 36, no. 3, June 1931, pp. 148-160, 9 figs. General description of apparatus and characteristics of its operation.

Testing Apparatus

HIGH TENSION. High-Voltage Testing Equipments, E. T. Norris and F. W. Taylor. *Instn. Elec. Engrs.,—Jl.*, vol. 69, no. 414, June 1931, pp. 44-694, 26 figs. State of art of high-voltage generation, to assist intending purchasers of high-voltage testing equipments in deciding upon best type of apparatus to install and in specifying most suitable technical characteristics, and to help owners and operators of existing equipments to appreciate possibilities and limitations of their apparatus and thereby make full and efficient use of it. Bibliography.

Transformers

TAP CHANGERS. Transformer Tap Changing on Load. *Engineer*, vol. 151, no. 3937, June 26, 1931, pp. 704-706, 13 figs. With view to meeting demand for step switches for pressure regulation on Load, Oerlikon Co. has utilized its experience gained in connection with traction gear, and has evolved various types of apparatus.

VAULTS. Typical Construction in Underground Transformer Installations, J. D. Pease. *South. Power Jl.*, vol. 49, no. 6, June 1931, pp. 57-58, 3 figs. Constructional features of three installations of commercial and industrial transformer stations in underground rooms.

Transmission

Is A-C. Power Transmission Doomed? C. W. Olliver. *Power Engr.*, vol. 26, no. 303, June 1931, pp. 210-211 and 229, 2 figs. A-C. power transmission was necessary evil, imposed by impossibility of static transformation; recent progress, by removing this obstacle, may well turn a-c. transmission lines into relics of past; series systems; field of application of d-c. generating system; advantages of d-c. long-distance transmission.

Transmission and Distribution

Transmission and Distribution, J. R. Beard and J. Hacking. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 414, June 1931, pp. 730-750. Brief account of present-day practise in regard to various component parts of transmission and distribution systems; subjects are dealt with under heads: overhead lines; cables; switchgear; transformers; protection and control. Bibliography.

Transmission Lines

CONSTRUCTION. Construction Methods in Erecting Hydro 220,000-v. Transmission Lines, G. R. Greer. *Elec. Canada*, vol. 8, no. 3, Mar. 1931, pp. 10-17, 8 figs. Construction experience and methods on line Gatineau-Toronto in Canada.

TOWERS. Transmission Tower Design for Maximum Lightning Protection, C. L. Fortescue. *Elec. Canada*, vol. 8, no. 3, Mar. 1931, pp. 18-23, and 32, 8 figs. Design analysis, curves showing effect of ground resistance with surge at tower for two and three ground wires; comparison of time-lag curves or sphere gaps and needle gaps; method of finding effective distance from ground wire to cloud; suggested arrangements when two ground wires are used; extrapolated average time-lag curves for needle gaps in air; time-lag curves of suspension insulators, with conductor positive.

Trolleys

TRACKLESS. The Trolley Bus as a Load Builder. *World Power*, vol. 15, no. 90, June 1931, pp. 465-469, 12 figs. Question of substituting trolley-bus or motor-bus service for street-car system; overwhelming economic advantages of trolley-bus service; analysis made of significance of street-car; load to electricity supply position in general and to municipal undertaking in particular.

Turbo-Generators

ROTORS. Turboalternator Rotors, W. R. Needham. *World Power*, vol. 15, no. 89, May 1931, pp. 375-376. General progress in rotor construction; influence of mechanical stresses on design.

U. S. INTERSTATE COMMERCE COMMISSION. Engineering in Its Relation to the Interstate Commerce Commission, F. McManamy. *Mech. Eng.*, vol. 53, no. 7, July 1931, pp. 503-509. Creation, organization, and duties of Commission; work of its various bureaus, including services of engineers in valuation, analysis of expenditures for equipment maintenance, and extensions; examination of specifications for locomotives, safety devices, etc.; determination of suitability of containers for transportation of explosives, etc. Before Am. Soc. Mech. Engrs.

Vacuum Tubes

RESEARCH. Electronic Tubes in the Laboratory. *Electronics*, vol. 3, no. 1, July 1931, pp. 24-25, 4 figs. Symposium of short notes by W. O. Watson, on Calibration of Grid Gain Controls; Glow-tubes Check Operating Voltage, by Gray Telephone Pay Station Co.; Progress in South Analysis and Measurement, F. Trendelenburg, of Siemens, Berlin; Graphic Noise Level Recorder, by Bell Telephone Laboratories.

Welding

BOILER MANUFACTURE. Boiler Manufacturers Discuss Welding at Annual Meeting. *Boiler Maker*, vol. 31, no. 6, June 1931, pp. 151-157. Application of fusion welding to construction of boilers and pressure vessels discussed at convention of American Boiler Manufacturers' Association; charts summarizing production of steel boilers from 1919 to 1930 inclusive; smoke prevention conference committee; cost accounting committee report; auxiliary equipment; work of feedwater studies committee; report of welding committee and discussion.

HOUSES, STEEL. An Arc-Welded Residence. *Gen. Bldg. Contactor*, vol. 2, no. 7, July 1931, pp. 33-36, 4 figs. Construction of two-story, six-room dwelling erected of arc-welded steel panels at Larchmont, N. Y.

PIPE LINES. Progress Made in Electric Arc Welding, C. M. Taylor. *Oil and Gas Jl.*, vol. 30, no. 2 to 4, June 4, 1931, (supp.) pp. T115-T116 and T118, 10 figs. Advantages of new welding process are explained by vice president of Lincoln Electric Co.; shielded arc produces welds of high tensile strength, ductility and resistive to corrosion; greater welding speed is obtained.

PRESSURE VESSELS. Fusion Welding and Its Use in Pressure Vessel Construction, W. D. Halsey. *Boiler Maker*, vol. 31, no. 5, May 1931, pp. 125-126. Because of recent rapid development in fusion welding, American Society of Mechanical Engineers' Boiler Code Committee has in course of preparation, code covering use in pressure vessel construction; attitude of insurer of such vessels towards process, and procedure to be followed in applying coverage for installations of such character.

SHIPBUILDING. Welded Machinery Foundations for Ships, G. H. Moore, Jr. *Welding Jl.*, vol. 28, no. 333, June 1931, pp. 172-175, 15 figs. Paper before Am. Welding Soc. previously indexed from their Journal, Apr. 1931.

Welds

STRESSES. The Distribution of Stresses in Welded and Riveted Connections, W. H vgaard. *Nat. Academy Sciences—Proc.*, vol. 17, no. 6, June 1931, pp. 351-359, 6 figs. Results of tests made at Massachusetts Institute of Technology; fundamentals of method. See reference to paper indexed in Engineering Index 1930, p. 1900, from issue of Nov. 15, 1930.

Industrial Notes

Carbon Brush Dimensions to be Simplified.—A meeting of the standing committee in charge of Simplified Practice Recommendation R56-28, Carbon Brushes and Brush Shunts, was held at the office of the National Carbon Company in Cleveland, Ohio, on July 28, 1931. Those present represented manufacturers of carbon brushes and brush shunts, motor and generator manufacturers, and users of motors and generators. The committee voted to reaffirm all items in the present recommendation with the exception of brush dimensions. In the opinion of the members, a further simplification of dimensions could be agreed upon by all parties concerned within the next few months. The committee therefore voted to hold in abeyance the publication of a revised recommendation until the new list, showing a smaller number of brush dimensions, had been approved by manufacturers of brushes, and of motors and generators. It is expected that this will be done within the next three months, and will result in largely reducing the number of stock items catalogued by all manufacturers.

The committee further voted to include in the revised recommendation certain additional definitions, together with a table showing the nomenclature recently adopted by the brush manufacturers to indicate the various standard types of shunt connections. It is also hoped that a further reduction can be made in the number of shunt lengths. Some of the manufacturers have already reduced the number of lengths from six to three. As soon as the necessary approval has been secured from the various associations interested, the final revision will be submitted to the division of simplified practice, which will then undertake to secure the written acceptance of the entire industry, in accordance with the regular procedure.

Pittsfield to Build Largest Transformers.—The largest transformers ever built at the Pittsfield works of the General Electric Company will be constructed for the Commonwealth Edison Company of Chicago and the Super Power Company of Illinois as part of an order for more than $1,000,000 worth of equipment. Delivery of the 20 transformers involved is expected early in 1932. So large are eight of the units that special drop-frame transformer cars must be built to ship them. The transformers will be used on both ends of a new 220,000-volt transmission line extending about 100 miles from Powerton to the Crawford Avenue station of the Commonwealth Edison Company at Chicago. For the receiving end, there will be required four 67,500-kva. power transformers and four 50,000-kva. regulating transformers. The power units, the heaviest, will weigh 491,000 pounds each, filled with oil.

Physically they will rival other big units made at the Pittsfield works in recent years. They will be 30 feet high overall, 27½ feet long and 19½ feet wide. In addition to these power units for the receiving station, there will be four regulating units, of 50,000-kva. output each, somewhat smaller in size and weighing 146,000 pounds each. At the sending end of the line there will be four 600,000-kva. units, weighing 406,000 pounds each, and eight 30,000-kva. regulating transformers weighing 75,000 pounds each.

Large Switch Order to Delta-Star.—The Pennsylvania Railroad Company has awarded the Delta-Star Electric Company, Chicago, a $150,000 contract for manual and motor operated disconnecting switches to be used on the railroad's extensive electrification project.

New Cap Type Connector.—The W. N. Matthews Corporation, St. Louis, announces the addition of cap type connectors to its line of solderless service connectors. Matthews connectors are now made in two styles, the new cap type and the nut type. The following advantages are claimed for the new connector: There are only two pieces to handle; the clamping lugs are made of bronze; hard drawn copper wire instead of soft drawn wire may be used. Bad connections are eliminated; it can be used much more economically for heavy loads where twisting large wires is difficult; radio interference due to twisted tap wires becoming loose is eliminated, because positive contact is assured and vibration will not cause loosening of the connector.

New Friction Tape.—The mechanical sales division of the B. F. Goodrich Company recently announced the development of a new friction tape especially designed for electrical use. The tape is similar to inner type patching material and practically vulcanizes in place after applied, making a solid covering for wire. The tape is listed by insurance underwriters and is approved for electrical purposes as taking the place of both insulating material and ordinary cloth tape, according to the manufacturer. The tape is so designed that it can be rolled lengthwise around electrical conductors, and is especially applicable to wiring where it is difficult to wrap the wire. It is made in ¾ inch and 1½ inch widths, packed in rolls.

Trade Literature

Wire Rope.—Catalog, 280 pp. Describes the complete line of Roebling wire rope and wire for all purposes. Wire tables are included. John A. Roebling's Sons Company, Trenton, N. J.

Panelboards.—Bulletin CA-505-A, supplement, 8 pp. Describes new Square D shallow type convertible safety panelboards with capacities up to and including 100 amperes, 250 volts. Square D Company, Detroit.

Speed Regulators.—Bulletins 1101, 1102. Describe ventilated and totally enclosed type speed regulators for use with constant torque and variable torque a-c. and d-c. fractional horsepower motors. Ward Leonard Electric Company, Mt. Vernon, N. Y.

Metal Enclosed Switchgear.—Circular 1915, 12 pp. Lists the installations of Westinghouse metal enclosed switchgear, includes photographs and descriptions. Circular 1899, 8 pp., describes this class of equipment in detail. Westinghouse Electric & Mfg. Company, East Pittsburgh.

"Frog Leg" Type Armature Windings.—Bulletin 2135, 4 pp. Describes this type of armature windings for multipolar, direct-current generators and motors. Such windings have been installed to date in over 500 units ranging in size from 50 kw. to 7,000 hp., totalling approximately 400,000 kw. Allis-Chalmers Manufacturing Company, Milwaukee.

Switchboards.—Bulletin 700, 90 pp. Includes specifications and design of Diamond "E" and Square D switchboards and panelboards. A detailed group of recommendations are outlined for dead front, live rear and dead front, dead rear switchboards and power panels. Diamond Electrical Manufacturing Co., 1318 E. 16th St., Los Angeles.

Insulators.—Catalog. Describes the complete line of Lapp insulators. It contains full data on electrical and mechanical characteristics, together with suggested applications. Insulator hardware is also covered. The catalog has an automatic index which enables the user to quickly find the product sought. A special section on distribution and farm lighting equipment is included. Lapp Insulator Company, Inc., LeRoy, N. Y.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 10

The JOURNAL of the A.I.E.E. for October 1931

C. E. Skinner, *President*
F. L. Hutchinson, *National Secretary*

Publication Committee

E. B. Meyer, *Chairman*
W. S. Gorsuch F. L. Hutchinson
W. H. Harrison H. R. Woodrow

Publication Staff

George R. Metcalfe, *Editor*
G. Ross Henninger, *Assoc. Editor*
C. A. Graef, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in ELECTRICAL ENGINEERING are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

REPUBLICATION from ELECTRICAL ENGINEERING of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index.

Printed in the United States of America.
Number of copies this issue—

23,000

This Month—

Front Cover

A monster of modern transportation. One of a fleet of electric locomotives recently placed in service by the New York Central Railroad. Six motors give a continuous rating of 2,025 hp. (2,500 hp. 1 hr.) and provide a maximum starting tractive effort of 66,500 lb., a 1-hr. rating of 41,800 lb. at 22 m. p. h., and a continuous rating of 31,620 lb. at 24 m. p. h.

—General Electric Co. Photo.

Arc Welding in Building Construction 785
By P. N. VINTHER

Solving the Mystery of Mercury Arc Rectifiers . . . 788
By ALBERT W. HULL AND HERBERT D. BROWN

Backfires in Mercury Rectifiers 793
By J. SLEPIAN AND L. R. LUDWIG

Losses in Mercury Rectifier Transformers 796
By E. V. DeBLIEUX

Corona and Line Surges 798
By H. H. SKILLING

Communication in Electric Power System Operation . . 802

- **Underlying Considerations of the Problem Outlined** . 802
  By R. N. CONWELL, G. M. KEENAN, C. F. CRAIG, E. C. BRIGGS
- **Communication in the Niagara Hudson System** . . . 805
  By E. S. BUNDY
- **Joint Study Improves Communication Facilities** . . . 807
  By C. A. BOOKER and M. E. CLARK
- **Communication in a Metropolitan System** 809
  By P. B. JUHNKE
- **Carrier Communication for Long Distances** 810
  By E. C. STEWART

—— Turn to Next Page

The Way to Progress and Prosperity 812
By C. E. GRUNSKY

The Simplex Synchronous Motor 814
By M. A. HYDE, JR.

Stabilization of Industry 816
By GERARD SWOPE

Synchronous Motors for Special Loads 819
By D. W. McLENEGAN and A. G. FERRISS

Relaying with Two Pilot Wires 824
By C. H. FRIER

Experiments with Short Arcs 827
By G. M. SCHRUM and H. G. WIEST, JR.

Repulsion Starting for Capacitor Motors 830
By EDWARD BRETCH

Distribution Systems for Industrial Plants 831
By W. J. McCLAIN

Electron Tubes for Industrial Control 831
By W. R. KING

Short Items—

Lumber Moisture Content Determined Electrically . . . 787
Severe Lightning Tests Made on Transformers 823

News of Institute and Related Activities . . 832

Letters to the Editor 840
Local Institute Meetings 841
Employment Notes 846
Membership 848
Engineering Literature 850
Industrial Notes 854
Officers and Committees (For complete list see pp. 771-776, September 1931 issue of ELECTRICAL ENGINEERING.)

NEWS section this month is replete with echoes of the recent A. I. E. E. Pacific Coast "vacation" convention. (*See pp. 832-5.*) Discussion on the technical papers presented is summarized also. (*See pp. 835-7.*)

THE electrical engineering profession suffered a distinct loss in the recent deaths of four of its noted members. (*See pp. 843-4.*)

THE widely heralded plan for stabilizing industry proposed by Gerard Swope (F'22) is presented in full in this issue. (*See pp. 816-9.*)

LETTERS received by the editor during the past month reveal increasing interest among readers especially in those articles dealing with the effects of engineering upon human relationships. (*See pp. 840-1.*)

LAST call is issued for the impending A. I. E. E. Kansas City meeting. (*See p. 834.*)

TESTS show that power-frequency corona is of no value in damping transmission-line surges. (*See pp. 798-801.*)

A NEW scheme of relaying with only two pilot wires instead of the usual four, materially reduces the cost of this type of protection. (*See pp. 824-6.*)

ENGINEERING FOUNDATION'S symposium, "Has Man Benefited by Engineering Progress," is continued this month by a protest against the indirect bonus system. (*See pp. 812-3.*)

SOME of the mysteries of mercury arc rectifiers are revealed in three articles by five engineers intimately connected with their development and application. (*See pp. 788-98.*)

A SERIES of tests involving all stages of the discharge casts further light upon the complex phenomena associated with the electric arc as used in welding. (*See pp. 827-9.*)

THOSE interested in electric motors and their applications are referred to two articles on special designs of synchronous motors (*see pp. 814-5 and 819-23*) and a third dealing with repulsion starting for capacitor motors (*see pp. 830-1*).

COMMUNICATION plays an important part in power system operation as is well demonstrated in a group of five articles outlining the fundamental requirements of power companies and describing the facilities in use on four typical systems. These represent the joint efforts of six power engineers and three communication experts of the Bell telephone system. (*See pp. 802-812.*)

Arc Welding in Building Construction

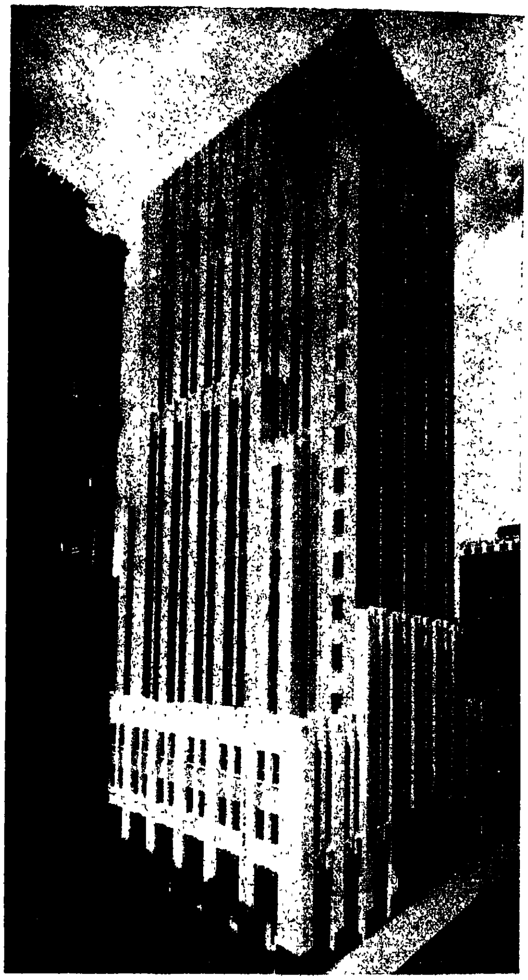
In this article are presented data obtained during the construction of the tallest building erected to date using the electric arc welding process. The outstanding advantages of this method of construction over the older method of riveting are (1) an almost complete absence of noise, and (2) the reduced steel tonnage required.

By
P. N. VINTHER Dallas Pwr. & Lt. Co., Dallas, Texas

WHILE electric arc welding has been used experimentally or commercially for more than half a century, its use in building construction extends back only three or four years. During these few years it has been applied successively to small, then to large and still larger projects until now because of its economy and quietness it is beginning to find favor in many quarters.

Because of its newness, most established building codes do not take cognizance of arc welding as a method of building construction. The first step in this direction was taken by the Pacific Coast Building Officials' Conference, which has included in its uniform building code the authority to use arc welding and has set forth therein the essential elements required by engineers and architects for working out designs of welded joints in steel beams and columns. A great many cities since have amended their codes to include arc welding; most of them have based their amendment on this Pacific Coast Building Officials' code. More and more municipalities are considering the advisability of adopting arc welding on steel construction as a means of obtaining quiet in the vicinities of hospitals, hotels, schools, and office buildings; wherever it has been used much satisfaction is evidenced.

The city of Dallas, principally through the efforts of local representatives of welding equipment manufacturers, legalized arc welding by ordinance in 1929. Accordingly the Dallas Power and Light Company, recognizing an opportunity to promote the use of electricity in a new field and to create a more livable condition for employees and neighbors during construction, concluded after thorough investigation to use welding in place of riveting in their new office building.



Nineteen-story arc-welded building of the Dallas (Tex.) Power & Light Company

This building is about 246 ft. high from basement floor to top of tank room roof, and is the tallest in the world to have employed this process to date. It consists of a nineteen-story main shaft (with basement) approximately 100 x 100 ft. at the base, and a 60 x 100-ft. connecting annex of two stories and basement. The main shaft is of modern design having an offset on the front at the sixth floor level and sym-

---

From "Electric Arc Welding in Building Construction," (No. 31M8) to be presented at the A. I. E. E. South West District meeting, Kansas City, M., Oct. 22-24, 1931.

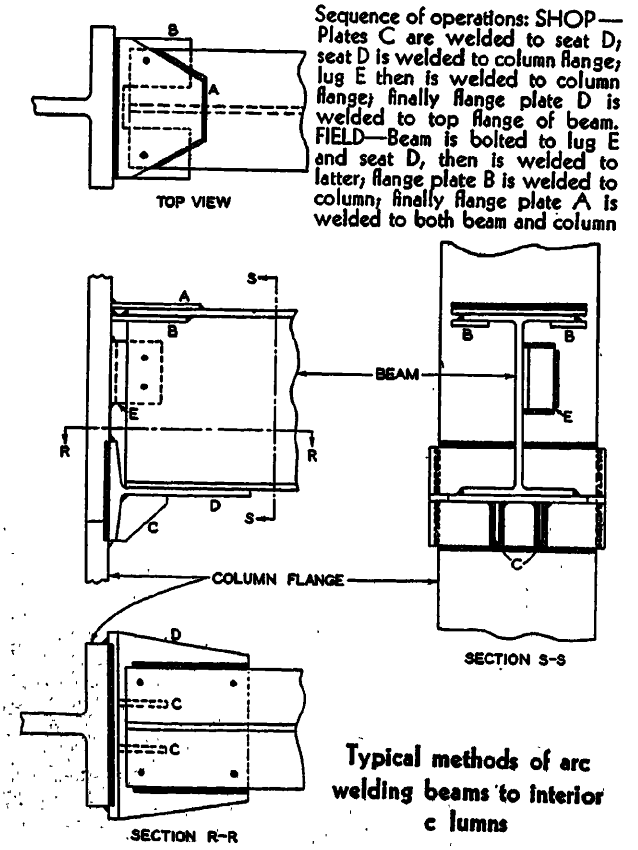
metrical setbacks on the two sides at the fourth and twelfth floor levels. The framing of this portion of the building consists of 25 H-section columns at the base spaced approximately 25 x 25 ft. and creating four 25-ft. bays each way. The width of the fourth floor setback is one-half a bay so that the outside columns from the fourth to the twelfth floors are carried on beams in the fourth floor. The twelfth floor offset is also half a bay, leaving the tower from the twelfth floor up two bays wide by the original four long, or approximately 50 x 100 ft. The sixth floor offset across the front is a minor one of only three or four feet and is carried by a second set of columns adjacent to the outside row, the outside row stopping with the offset and the adjacent row extending through to the top.

The second floor of the annex and the seventeenth floor of the main shaft are auditoriums. The second floor auditorium is spanned by five welded Warren trusses approximately 5 x 60 ft. The seventeenth floor auditorium, which really is two stories high, is spanned by three 12 x 50-ft. shop- and field-welded trusses, which not only support the ceiling of the seventeenth floor but carry on their bottom chords the nineteenth floor and on their top chords the roof, so that the nineteenth floor has the truss height for story height. The total weight of the steel is 1,170 tons for the main building and 45 tons for the annex. The steel was fireproofed with concrete, all of the slabs being of the pan and joist type poured on removable wooden forms. The building is provided with heavy wind bracing in both directions.

Since the success of welding depends upon the skill of the welders, the utmost care was used in selecting and training the mechanics employed. Each applicant was required to pass a rigid proficiency test before he was allowed to work. Only those welders whose specimens broke down at or above certain minimums set up for each type of weld were considered and then only provided their specimens showed uniformity in strength and appearance. While a good and uniform appearance in a weld does not of itself contribute directly to strength it is interesting to note that almost invariably the best looking work tests highest. For this reason a visual inspection is as effective as any other means yet devised, although certain mechanical and electrical methods now are being developed that no doubt some day will come into general use as an aid to the eye and sense.

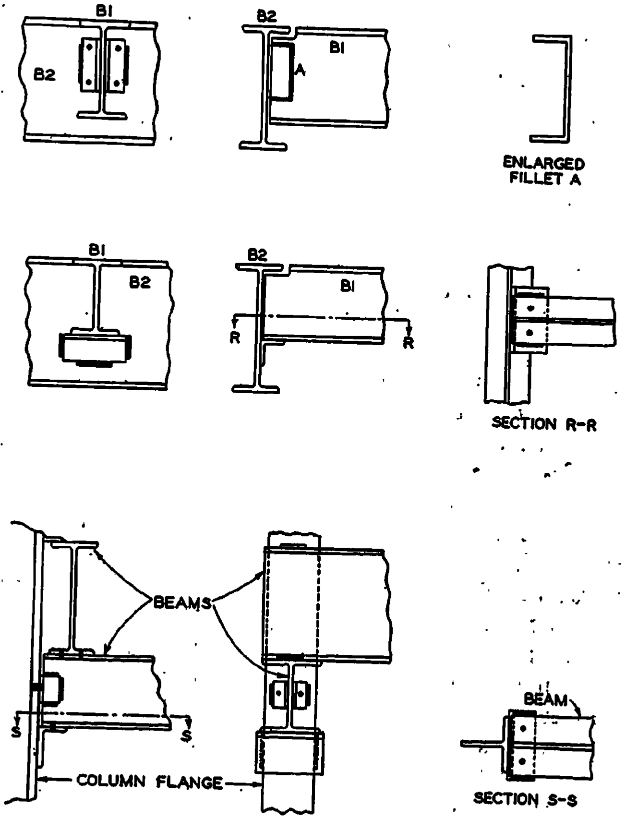
Welding equipment consisted of five 200-ampere portable motor-driven units of standard design, each used by a single mechanic.

The joining of the horizontal members or a horizontal



Sequence of operations: SHOP—Plates C are welded to seat D; seat D is welded to column flange; lug E then is welded to column flange; finally flange plate D is welded to top flange of beam. FIELD—Beam is bolted to lug E and seat D, then is welded to latter; flange plate B is welded to column; finally flange plate A is welded to both beam and column

Typical methods of arc welding beams to interior columns



Typical methods of arc welding small beams to larger beams and columns

Connecting angles are shop welded to small beams, and field welded to larger beams or columns. Shelf angles are shop welded to larger beams or columns member to a vertical member was accomplished by resting one member upon and field-welding it to a shelf shop-welded to the other. These shelves afforded not only a rest for members until welding could be completed, but also provided location for temporary construction bolts which, together with the customary cables and turnbuckles, were used in erection. Additional angles, I's and gussets then were added and the necessary amount of welding, measured in inches, was applied to provide the required strength. Care was exercised in the location and arrangement of these auxiliary pieces that as much of the welding as possible might be done at the shop and that overhead welding might be held to a minimum. Column splices were made by butting the ends together at the field and adding splice and filler plates, then welding to the required strength. Typical connection details are shown in the illustrations.

Most of the pertinent data collected during erection is given in the accompanying tabulation.

Arc-welding data for the Dallas Power & Light Company's nineteen-story building

Item	Description		Shop	Field
1.	Electrode bought	Lb	7,100	4,650
2.	Electrode melted (assumed 70%)	Lb	4,970	3,255
3.	Energy used	Kw-hr.	No record	9,460
4.	Total steel welded	Tons	1,215*	1,170*
5.	Welders' time	Man-hr.	3,140	1,768
6.	Total length of 3/8-in. fillets	In.	97,500	56,415
7.	Total length of 1/2-in. fillets	In.	25,400	17,842
8.	Total length of all fillets	In.	122,900	74,257
9.	Fillet per ton of steel	In.	101.2	63.5
10.	Fillet deposited per man per hour	In.	29.2	42.0
11.	Fillet deposited per man per 8-hr. day	Ft.	26.13	28.0
12.	Fillet deposited per lb. of electrode bought	In.	17.3	16.0
13.	Fillet deposited per lb. of electrode melted	In.	24.7	22.8
14.	Fillet deposited per kw-hr	In.	—	7.9
15.	Electrode melted per kw-hr	Lb.	—	0.34
16.	Energy required to melt 1 lb. electrode	Kw-hr.	—	2.90
17.	Welding man-hours per ton of steel	Man-hr.	2.58	1.51
18.	Electrode bought per ton of steel	Lb.	5.84	3.98
19.	Electrode melted per ton of steel	Lb.	4.08	2.78
20.	Electrode melted per hour per welder	Lb.	1.58	1.84
21.	Electrode melted per linear inch of fillet	Lb.	0.040	0.044
22.	Energy required per ton of steel	Kw-hr.	—	8.09

*Difference between shop and field tonnage due to 45 tons in a two-story wing not included in record.

Erection of the building was begun on July 18, 1930, and was completed September 3 of the same year. Field-welding operations were started on July 23, being completed September 11. In the completed building only two or three evidences remain to testify against the welding process and each of these could have been eliminated had the designers of the building possessed the experience that now is theirs.

Great progress in welding is being made. Many new problems are encountered on every job and are being worked out. The summation of the solutions of all these problems will constitute a goodly store of knowledge from which the architect and engineer may be able to design simply and practically and the contractor to fabricate economically. Even then prejudice in the minds of the non-progressive element will have to be overcome. Possibly new weights and shapes of members will have to be devised in order to reap most fully the benefits of the possibilities for reduced tonnage. Whatever are the obstacles in the path of the development in the art they all will be overcome with time. While at present it cannot be said that welding is due to supplant riveting in every kind of steel job, there is no doubt that the increasingly congested condition of commercial areas and the increasingly insistent demand on the part of the people therein for quiet will keep engineers, architects, and scientists busy.

Lumber Moisture Content Determined Electrically

THE OPERATION of determining accurately the amount of moisture present in lumber is reported to be greatly simplified by an electrical apparatus developed by C. G. Suits of the General Electric research laboratory, Schenectady, N. Y., and M. E. Dunlap of the United States Forest Products Laboratory at Madison, Wis.

The device utilizes simple tuned circuits involving two neon glow lamps. One of the neon lamps is

Portable electric lumber-moisture tester connected across a fixed condenser so adjusted that as the condenser successively builds up and discharges, this tube produces a characteristic red flash at the rate of about once per second. The other neon tube and its associated condenser are in series with the knife-edged electrodes on the specially treated wooden hammer. These electrodes, when driven into the grain of the lumber to be tested, complete an electrical circuit the characteristics of which depend upon the resistance of the wood between the two hammer electrodes. The rate at which this condenser builds up its charge depends upon the conductivity, and therefore upon the moisture content, of the wood under test. By means of a variable condenser this second tube circuit is adjusted so that the two tubes flash simultaneously, thus permitting the dial reading of the variable condenser to be calibrated to reveal the percentage of moisture in the lumber under test. Ear-phones may be substituted for the neon tubes where bright sunlight interferes with the visual effect of the tube flash.

Investigations indicate that with the exception of certain heavy imported woods, dependence may be placed upon the determination of moisture content as revealed by such a resistance test.

Solving the Mystery of Mercury Arc Rectifiers

By
ALBERT W. HULL
Non-member

HERBERT D. BROWN
Associate A. I. E. E.

Both of
General Electric Co.,
Schenectady, N. Y.

The three factors most important in mercury arc rectifiers are vapor pressure, arc-drop, and geometry of the anode housing. Investigations of such factors described in this article, have increased the capacity of rectifiers considerably and made it possible to eliminate several undesirable features of their operation.

EXPERIMENTAL research during the last three years has removed much of the mystery which shrouded the mercury arc rectifier, and made it a piece of standard electrical apparatus comparable to the motor and transformer. Much remains to be learned but these investigations have expanded greatly the range of current and voltage that can be handled by a rectifier and have indicated the path for still further progress.

The differences between the early rectifiers and the more modern type illustrated in Fig. 1 are mostly in the neighborhood of the anodes. One conspicuous change may be dismissed with a very brief statement, *viz.*, the change from mercury-cooled iron anodes supported by porcelain bushings, to graphite anodes with micalex bushings. The micalex seal is made from a mixture of mica and lead borate glass, fused and molded under high pressure, yielding a vacuum-tight seal of high mechanical and dielectric strength. This allows the clamped seal to be metal-metal instead of metal-porcelain, thus avoiding differential lateral expansion.

The normal operating requirements of a rectifier are very simple:

1. It must start easily, *i.e.*, it must begin rectifying whenever the a-c. crest voltage exceeds the d-c. line voltage by a small margin, of the order of 20 volts.

2. It must not arc back, *i.e.*, allow current to pass in the reverse direction.

3. The voltage drop between anode and cathode, when current is flowing, must be low enough to meet the efficiency requirements. The practical limits of voltage drop, which are approximately 20 volts minimum and 40 volts maximum, are generally satisfactory for line voltages of 500 or more, but are too high for 250-volt operation. The hot-cathode rectifier promises to fill this gap.

4. Voltage regulation will be required in the future. This is a circuit function rather than a rectifier function in the case of a simple rectifier, and can be accomplished by transformer compounding; but grid-controlled rectifiers of the type illustrated in Fig. 1, called thyratrons, can be made to give any desired regulation without compounding.

The arc-back requirement has received most attention up to the present, because the greatest electrical sin of today is interruption of service. When a rectifier arcs back it is a two-way conductor instead of one-way and hence constitutes a short circuit of the a-c. supply line as well as the d-c. line or network which it feeds. The harm done by such short circuits, assuming they are cleared by circuit breakers, is mainly interruption of service.

The gas evolution accompanying arc-back, if excessive, may delay resumption of service until the pumps can restore the necessary vacuum. Fast pumps and

---

From "Mercury Arc Rectifier Research," (N . 31-49) presented at the winter convention of the A. I. E. E., New York, N. Y., January 26-30, 1931.

well-degassed anodes have reduced this time to the order of one minute, and experiments now in progress are expected to reduce it to one second or less.

CONTROL OF MERCURY VAPOR PRESSURE

The most important single factor in mercury arc rectifier operation is the control of the mercury vapor pressure. This pressure depends on the temperature of the cooling water. The problem for investigation divides itself into two parts: (*a*) Assuming that the cooling-water temperature is uniform, what is the best temperature, and what are the permissible temperature limits? (*b*) If the water is not uniform, in what parts of the rectifier should the temperature be controlled?

The optimum temperature may be determined empirically by gradually increasing the load current at a given water temperature until a limiting temperature is reached, above which the rectifier will not operate at any load. Uniform temperature of the cooling water is maintained by rapid circulation. In this way a load-temperature curve is obtained, as shown in Fig. 2. The ordinates represent the maximum safe load for reliable short-time operation at each temperature. The important fact to be noted is that, while operation is possible at any temperature below a definite maximum, the load that can be carried is small at low temperatures and increases uniformly with temperature. The best operating temperature therefore is as near the maximum as can safely be maintained; and for a given load there is a definite operating range of temperature. For example, for the rectifier represented in Fig. 2, the operating range for a load of 1,500 amperes is between 42 and 60 deg. cent., as indicated by the shaded area. It is seen that there are two limitations to the range of reliable operation at a given voltage. One is high temperature, *i. e.*, high vapor pressure of mercury; the other is high current.

The maximum vapor pressure for a given operating voltage may be expected to follow closely the relation between vapor pressure and sparking potential; in fact, the only difference to be expected between arc-back potential and sparking potential is the change in the surface condition of the negative electrode, due to the presence in and just below the surface of gas molecules which have penetrated the surface in the form of positive ions. Such a composite surface is known to emit electrons more easily than a pure metal surface, and may be expected to allow a spark discharge at lower voltage. Hence the arc-back voltage should be very close to the sparking potential between electrodes of low electron work-function.

This conclusion appears to be justified by the results of a large number of tests made of sparking potentials. Typical results are shown in Fig. 3 which gives the sparking potential of an idle iron anode in a rectifier having 15-cm. diameter arms, with and without current to an adjacent anode. It is seen that the presence of ions due to current in the adjacent arm lowered the sparking potential by 50 per cent for the same vapor

Improving the Mercury Arc Rectifier

SOME of the problems most important to the successful construction of mercury arc rectifiers are discussed on these and the following nine pages. The first article, that by Hull and Brown, is a general treatment of the research problems which are being encountered in improving such rectifiers. Investigations are described of the three factors which the authors believe to be most fundamental; namely, vapor pressure, arc drop, and geometry of the anode housing. The second article, by Slepian and Ludwig, is concerned principally with the cause and occurrence of backfire in mercury-arc rectifiers, together with possible means for reducing the frequency of its occurrence. The authors point out that the random nature of backfire is not always appreciated, but that an understanding of this characteristic is essential to its elimination. The third article, by DeBlieux, is concerned with the losses in transformers for use with mercury-arc rectifiers, and introduces methods of calculating and testing the losses in these transformers independent of the rectifiers.

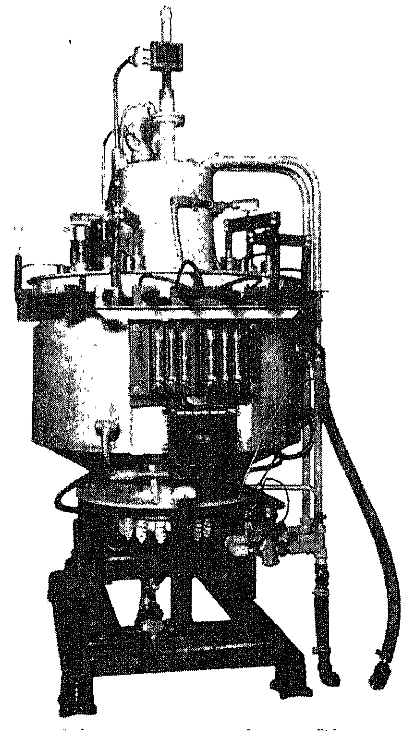


Fig. 1. Rectifier of recent design, with graphite anodes, subdividing grilles, and control grids

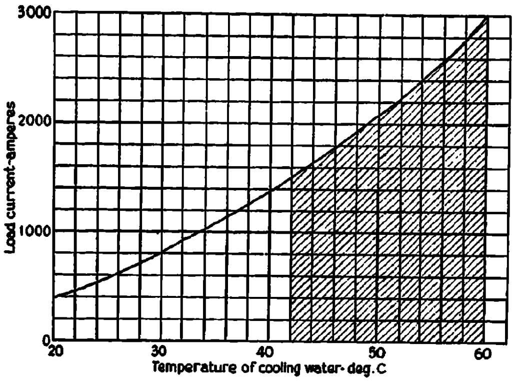


Fig. 2. Load-temperature curve for loads of 1 min. duration at 3,000 volts on a six-anode rectifier similar to Fig. 1, with 15-cm. diameter arms

pressure; or, conversely, lowered the vapor pressure for the same sparking potential by 50 per cent. Vapor pressure doubles for each 10 deg. temperature.

The current limitation is of a different nature. It is due to a complete utilization of the mercury vapor in the anode arms, the maximum load current being that which utilizes all the molecules of the vapor as positive ions to neutralize the electron space charge.

The vapor pressure in the anode arms is not completely determined by the temperature of the cooling water in the case of continued heavy loads, because of the temperature gradient in the iron wall and the iron-water boundary, and under some conditions, a pressure gradient in the mercury vapor due to convection of mercury spray and its vaporization in the arc stream. Differences as great at 10 deg. cent. between water temperature and equivalent vapor pressure have been observed and even greater differences may exist. Hence, when the water temperature is adjusted to give the maximum safe vapor pressure in order to carry the maximum load, if this load is maintained the pressure will rise above the safe value. This results in a load-time characteristic such as shown in Fig. 4.

A series of simultaneous measurements was made of vapor pressure in the anode arms and temperature in different parts of the tank, during normal low-voltage operation. It was found that with light loads the vapor pressure in the anode arm corresponds very closely to the temperature of the part just beneath the anode arm, and is nearly independent of the temperature of the rest of the rectifier.

ANODE HEATERS

The limits of vapor pressure are almost certain to be momentarily exceeded if mercury in a liquid state comes in contact with hot anodes or any hot surfaces near the anodes. In some of the early models it was observed when they were opened that the anodes and their housings were thickly coated with small drops of mercury which had condensed as the rectifier cooled. These rectifiers were known to arc back frequently within the period between 20 min. and 2 hr. after starting, which was about the range of time required under vaying loads for the anodes and housings to become hot enough to vaporize mercury rapidly, and thus lead to excessive local pressure with resultant arc-back. Heaters were therefore installed in the anodes and housings at a temperature higher than the body of the rectifier, so that condensation could not occur. The result was the entire disappearance of the 20-min. to 2-hr. arc-backs, and, in fact, of nearly all arc-backs.

VOLTAGE DROP

The pulse of a rectifier is the voltage drop between cathode and anode when the anode is positive. It is a valuable index of health, especially in studying or conditioning a new rectifier. For example, an exceptionally low voltage drop tells that the vapor pressure is abnormally high, and arc-back may be expected with continued load; a high voltage drop indicates excessive load, which must be reduced or the vapor pressure raised if reliable operation is to continue. If one anode has a higher voltage drop than the others it contains foreign gas, due either to leakage or incomplete exhaust; if lower, its grid has probably been injured during assembly or exhaust.

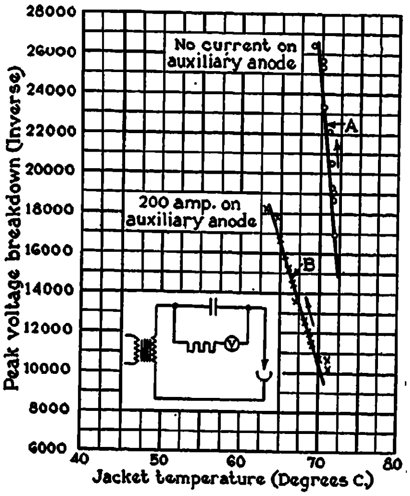


Fig. 3. Sparking potential of an idle anode in an iron-anode rectifier, as a function of mercury vapor pressure

The slope or "resistance" of the voltage—current characteristic is negative for small currents, zero for moderate currents, and positive for large currents, as shown in Fig. 5. The negative portion of the characteristic is well known. The positive portion is observable only with low-pressure arcs, and is due to the approach to complete utilization of all the gas. When volt-ampere characteristics are obtained for different vapor pressures, it is found that the current at which the characteristic becomes positive is proportional to the vapor pressure, as may be seen in the figure. This is to be expected from the point of view previously expressed that positive resistance is due to full utilization of the mercury vapor.

Using a peak-reading vacuum-tube voltmeter in a group of tests simulating operating conditions, it was found that arc-back usually occurs when the voltage drop exceeds about 50 volts. Hence the maximum load which a rectifier can carry may be predicted from the intersection of its volt-ampere characteristic with the 50-volt line. Excessive voltage drop is usually accompanied by surges which excite oscillations of the transformer system, sometimes of sufficient voltage to arc over insulation.

If the positive resistance shown in Fig. 5 represents a true instantaneous characteristic of the arc, it should be possible to operate such arcs in multiple for large currents without the use of stabilizing resistance or reactance. This was tested in a 24-anode rectifier, the anodes of which were arranged in two concentric rings of twelve each and connected in pairs to the terminals of a twelve-phase transformer, each pair consisting of one anode of the outer group and one of the inner group. The length of the arc path to the outer anode was sufficiently longer than that to the inner anode that an unfavorable condition for division of current existed.

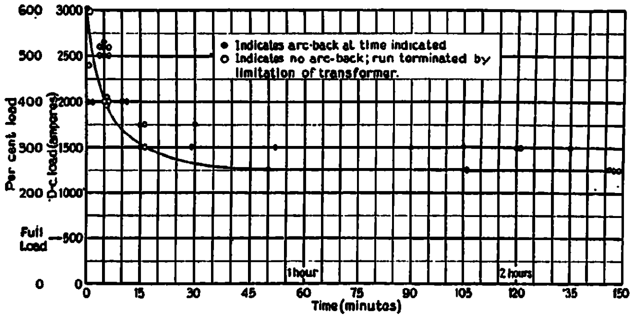


Fig. 4. Arc-back characteristic of same rectifier as in Fig. 3, at 3,000 volts and 60 deg.

From the characteristic given in Fig. 5 we should expect one anode of each pair to carry all the current for light loads for which the characteristic is negative, and for a small portion of the positive range, up to the current value at which the voltage drop is equal to the voltage drop for zero current of the other anode of the pair; at loads greater than this, both anodes of each pair will carry current, and will carry it more and more equally as the load increases. The current actually observed for several pairs of anodes conforms completely to the values predicted from the characteristic arc-drop curve.

As additional evidence of the approximately equal division of current, the rectifier was tested for current-capacity, first with one set of anodes alone, and then with the two sets in parallel. It was found that the rectifier would carry twice as much current with the parallel anode connection as with either set of twelve anodes alone. Further readings taken with an oscillograph agree with the load-limit test in showing that the load capacity is doubled by doubling the number of anodes and using them in pairs, each pair being in multiple without stabilizing reactance.

Geometry of Anode Arms

Since as previously shown the temperatures that determine the current capacity are almost entirely those near the anode arms, it may be anticipated that the important dimensions will be those of the arms. This has been found to be true. It has been shown, however, that for geometrically similar plain cylindrical arms, the capacity is nearly independent of the dimensions of the arms. The reason that the current does not increase with diameter is that the maximum safe operating temperature decreases as the diameter of the arm increases. Thus the total amount of vapor in the arm, and hence the current capacity, should remain about constant in agreement with observation.

The behavior is very different when the anode arm is subdivided so as to be equivalent to a group of small arms. If the part of the arm just below the anode is divided by metal vanes into narrow parallel channels, the limiting vapor pressure is determined by the dimensions of these channels and their distance from the anode, and is independent of the diameter of the arm. Under these conditions the current capacity is proportional to the square of the diameter, that is to the cross section of the anode arm. This is shown in Fig. 6.

This agrees with the previously described test for parallel operation which indicates that if any number n of adjacent anodes are grouped in parallel as a unit, without stabilizing resistance or reactance, the current which they can carry safely is n times that of a single anode. The group of parallel-connected anodes may

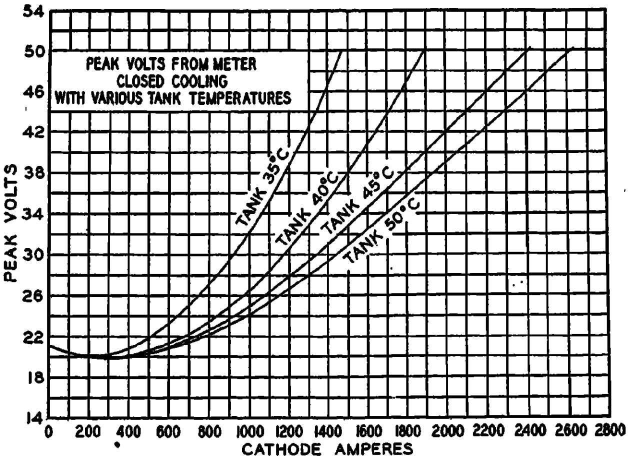


Fig. 5. Voltage drop in a mercury arc as a function of current

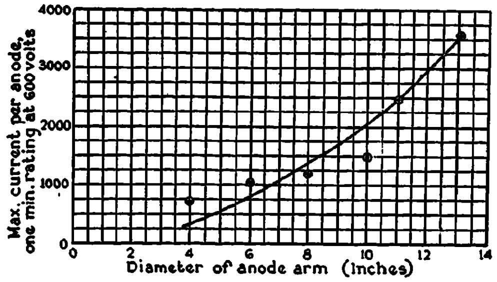


Fig. 6. Test points of current capacity for subdivided graphite arms. The solid line represents the theoretical limiting value of 4 amperes per sq. cm.

obviously be connected together inside the rectifier instead of outside, which is equivalent to combining them into one large anode with a number of parallel paths leading to it, each path similar in dimensions to one of the single anode arms. This is the principle of subdivided arms.

Their use has been very carefully tested, using partitions of different forms and dimensions, and anode arms from 15 to 33 cm. diameter. The results show that with a given "mesh" of subdividing partition, the current that can be carried is proportional to the total cross section of the arm, as it should be. The maximum operating vapor pressure, and hence the current per unit cross section, depend upon the dimensions of the partitions.

GRIDS AND THEIR USES

Grids or grilles consisting of parallel passages longer than they are wide may perform the function described above of enabling rectifiers to operate at a higher vapor pressure than is possible without these grilles. The sparking potential of a gas decreases with decreasing pressure, as is well known, to a minimum value, and then increases rapidly with further decrease of pressure. At pressures above that corresponding to the minimum, the sparking potential is higher the greater the distance.

The tungar rectifier operates above the minimum, *viz.*, at 5-cm. mercury pressure of argon. It might seem that advantage could be taken of this fact to increase the arc-back voltage of the tungar rectifier by increasing the distance between electrodes; for example, at 2-cm. distance the sparking potential is 1,800 volts. The answer is that it is impossible to maintain this distance under rectifying conditions, for the ionized gas that is left between the electrodes at the end of the rectifying cycle forms a conducting sheath around the positive electrode, building it out until its distance from the negative electrode is that corresponding to minimum sparking potential. This applies to all pressures higher than the "minimum" and all reasonable electrode distances.

It is evident therefore that high-voltage rectification can be accomplished, if at all, only in the range of pressure below the minimum point. In this range the sparking potential is higher the smaller the distance between electrodes. With an anode arm 30 cm. in diameter the effective sparking distance between anode and wall is of the order of 60 cm. At this distance the pressure of mercury vapor corresponding to a sparking potential of 6,000 volts is approximately 0.003 mm. The function of the grille is to decrease this distance and thus allow a higher operating pressure. For example, by placing a grille 5 cm. below the anode the distance is decreased from 60 cm. to 5 cm., and the pressure thus increased from 0.003 mm. to about 0.040 mm.

The form of the grid is important if it is to perform this function of shortening the distance between anode and body of the rectifier. Tests have shown that wire grids, unless their mesh is very fine, are not effective in shortening the distance, since the ions diffuse freely through the holes. On the other hand, partitioned passages or grilles like those described above do not allow ions to diffuse through, provided the length of the passages is large compared to their width.

Another use of the grid is to control the starting of an arc, rectifiers equipped with such grids being called thyratrons. Any type of grid can perform this function provided it is insulated, and the voltage that must be applied to it to allow or prevent starting of the arc depends upon its location and fineness.

One application of thyratrons is the use of the grid for obtaining automatic voltage regulation. The principle of this regulation is that the phase of the voltage applied to the grids is automatically advanced as the load increases. This is obtained by having the grid voltage derived from a current transformer in the line, so connected that its variable output voltage is added to a 90-deg. lagging constant voltage derived from a selsyn transformer. The constants are so adjusted that at light load the anode current starts late in the cycle, advancing with load until at the desired overload it starts at the earliest possible starting time, namely, the time at which the anode voltage rises above the rectified d-c. line voltage.

HOT-CATHODE RECTIFIERS

Hot-cathode rectifiers, although not yet developed for large capacities, have many features which make them attractive. One of these is the ease of control of the mercury vapor pressures. A single drop of mercury suffices and this may be located in the coolest part of the tube remote from the arc so that the temperature of this part will determine completely the vapor pressure throughout the tube. The rest of the walls may be as hot as desired, thus permitting a considerable reduction in size of the rectifier.

Another advantage of hot-cathode rectifiers is low voltage drop with resulting efficiency at low operating voltage. Three factors contribute to this low voltage drop. In the absence of mercury spray the distance between the cathode and anode may be short; an "efficient" cathode material, such as barium requiring but two watts per ampere, may be used; and a wide choice of gases is available. Thus hot-cathode rectifiers promise to fulfil the future requirements of low-voltage applications with an efficiency of 95 per cent or better at 250 volts, and well over 90 per cent at 100 volts.

Backfires in Mercury Rectifiers

Successful operation of mercury arc rectifiers requires the almost complete elimination of backfires. Studies made to eradicate this evil should recognize that backfires do not occur at some given stress, but are random in their nature. There is, however, an average rate of backfire which determines the reliability of a rectifier.

By
J. SLEPIAN
Fellow A. I. E. E.

L. R. LUDWIG
Associate A. I. E. E.

Both of
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

IN A mercury arc rectifier operating normally, each anode carries a large current when it is at a positive potential with respect to the cathode and a very small current (a few milliamperes) when it is at a considerable negative potential with respect to the cathode. It was found early that with the simplest and most obvious constructions this normal operation was not reliable, and was not reliable in an erratic way. An anode would function properly for perhaps thousands of cycles, and then suddenly fail to hold voltage when negative in some particular half cycle. With the usual rectifier circuits, such failures result in a short circuit and they are termed "arc backs" or "backfires."

The causes of these backfires are still not well understood, but it was found early that certain constructions reduced the likelihood of their occurrence. For example, cooling of the rectifier by introducing condensing chambers, water jackets, etc., keeps the vapor pressure low and reduces the backfire frequency. Also, moving the anodes away from above the cathode, placing them in shields, and placing grids in these shields such that they were interposed in the arc path, aided in reducing the chances of backfire. However, these remedial measures greatly increased the size and cost of rectifiers; and increased their arc drop, thus decreasing the efficiency. Consequently the whole design of the present day rectifier is predicated on the reduction of backfire frequency, and the means employed result in a rectifier for 600-volt service which is nearly as expensive as a rotary converter, scarcely more efficient and probably still less reliable. Clearly, research devoted to advancing the application of mercury arc rectifiers must consist of a study of backfire which will yield means for reducing the tendency without losing the attractive features of mercury arc conversion.

BACKFIRES—A RANDOM PHENOMENON

A striking feature of rectifier operation is the erratic manner in which backfires take place. Yet the great significance of this erratic behavior and its implications as to the operation which may be expected, do not seem to have been generally grasped. It is essential to recognize that except for backfires due to certain grosser causes, which will be mentioned later, backfires are inherently a random phenomenon in that they do not take place immediately when a definite limiting stress is reached, such as, for example, when some limit of current, voltage or vapor pressure is exceeded. Backfires occur in a random manner under all operating conditions, but with an average frequency which depends on the conditions of operation. Hence a backfire is very unlike the breakdown of a spark gap, which is certain to take place if the potential difference across the gap is increased beyond a definite value. Backfires do, however, resemble many other examples of random or inherently erratic phenomena well known in physics, such as the Brownian movement, the disintegration of radium, or the fluctuation in the density of a gas when sufficiently small volumes of the gas are considered, and like these phenomena, backfires probably depend for their occurrence upon aggregates involving relatively small numbers of atoms, molecules, ions or electrons.

The entirely random occurrence of backfires in time may be illustrated by Fig. 1, which was obtained with a small metal tank rectifier, with all controllable variables held as nearly constant as possible. The probability of backfire of a rectifier is a particular condition and during a short time interval Δt may be defined as follows. Imagine a large number of tests N, made with a rectifier under identical conditions, the

---

From "Backfires in Mercury Arc Rectifiers," (No. 31-132) to be presented at the A. I. E. E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

time duration of each test being the interval Δt. Suppose that backfires occur in a certain number of these tests n, but not in the others. Then $\frac{n}{N}$ will be the probability of having a backfire in the time interval Δt, and if we write $\frac{n}{N} = p\,\Delta t$, then p is the probability of backfire per unit time.

It can be demonstrated that if the probability of backfire remains constant, and if the time intervals between successive backfires are observed, then the proportion of these time intervals which is greater than a given time T is e^{-pT}. That is $\frac{m}{M} = e^{-pT}$, where m is the number of intervals greater than T in length, and M is the total number of intervals. This relation has been confirmed experimentally with a metal tank rectifier having a constant current arc going to one anode and a negative test voltage on the other, with the result shown in Fig. 2.

The state of a rectifier with respect to backfire is properly described when a mean frequency of occurrence of backfire is given. It cannot be described by saying that the rectifier is operating above or below backfire limits, inasmuch as there are no definite backfire limits. The mean frequency of backfire depends on the construction of the rectifier, and on the conditions under which it operates. There are probably no commercial rectifiers which have a mean backfire frequency of zero; but a mean frequency as small as once in a few years is of course low enough to give more than the degree of reliability satisfactory for operating purposes. The backfire frequency of successful rectifiers in the field seems to be of the order of several per year.

TESTING OF RECTIFIERS

Commercial tests on rectifiers are made to determine their quality, which must be found in terms of an average backfire rate. Since this rate is very low for commercial rectifiers, its determination by usual tests is practically impossible. For example, suppose that a large number of rectifiers were made with such uniformity that each had an average backfire rate of once per month. If they were tested by the manufacturer for one month, which is impractically long, the mathematical probability is that 37 per cent of the rectifiers would not backfire, another 37 per cent would backfire once, and only 26 per cent would backfire twice or more. Consequently such a test would not show the true reliability of the rectifiers.

The way out of this dilemma seems to be to test the rectifiers under abnormal conditions which would make the average backfire rate countable in a reasonable length of time and to have data which will permit extrapolation for determining the backfire rate under normal conditions. For example, if the dependence of backfire rate upon test voltage is well established for a given type of rectifier, the tests might be made at such overvoltage as will give a countable rate in one day. Extrapolation to normal voltage would then give the expected backfire rate under normal conditions.

The variation of backfire rate with voltage for a small two-anode metal tank rectifier is shown in Fig. 3. The average breakdown rate was found to vary exponentially with the voltage. Current of 48 amperes was kept flowing to one anode, and a negative voltage was continuously applied to the other, grid-glow tube relays being used to record the backfires automatically. Tests were made at various times, and because of day to day variation as the quality of the rectifier changed somewhat for unknown reasons, different straight lines were obtained. All the data lay between the dotted lines shown in the figure.

Both iron and graphite anodes are extensively used by rectifier manufacturers. Tests at abnormal voltages on the relative average backfire rates with these two materials have shown that a few more backfires occur in a given time with iron than with graphite, but the

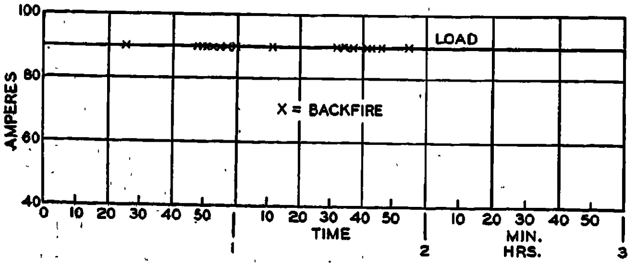


Fig. 1. (Above) Random occurrence of backfire on a small metal tank rectifier

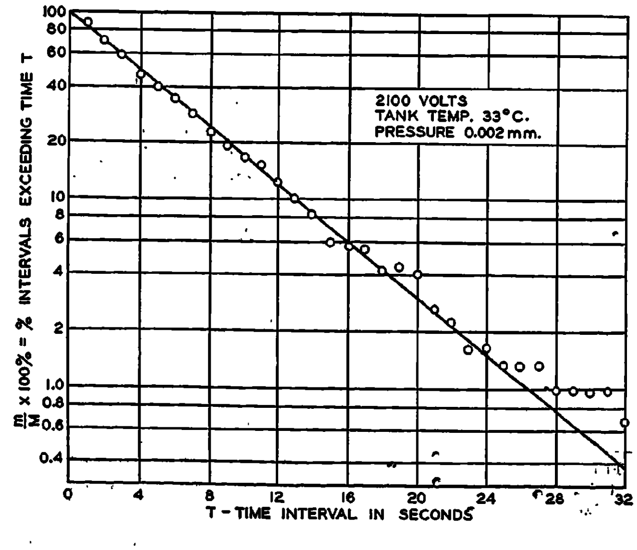


Fig. 2. (Right) Percentage of intervals between backfires exceeding time length T, in terms of time T

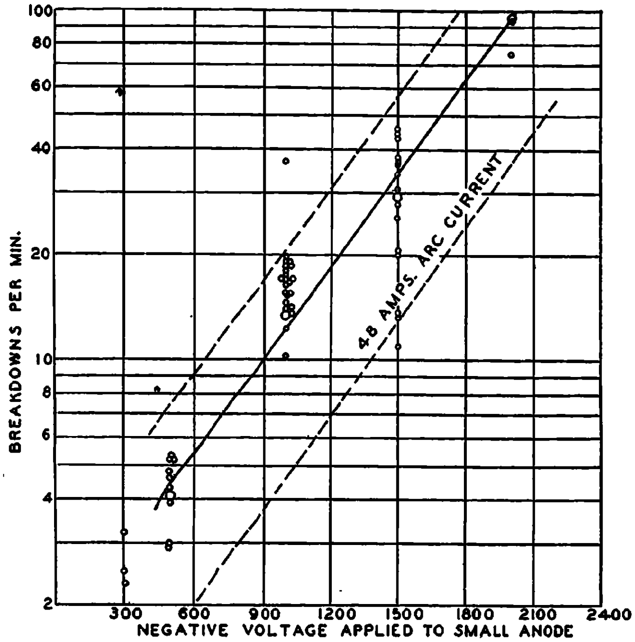


Fig. 3. Variation in average backfire rate with voltage for a metal tank rectifier

difference is no greater than day to day variations with either material. Consequently, no decided advantage of either material is indicated from a standpoint of backfire rate alone.

CAUSES OF BACKFIRES

In addition to random backfires, certain grosser backfire causes which will not be random may occur in practical rectifiers. An example is the starting of an arc due to the blowing up of a conducting deposit formed over an insulator from anode to tank, the action being similar to that of a fuse. Direct observation shows, however, that such grosser causes are avoided in well-built rectifiers and that most backfires occur directly on the anode surface. It is these latter backfires, which are of the random type, to which we wish to give further consideration.

According to present available theories of the cathode of an arc, backfire should never occur without some initiating circumstance foreign to the kind of discharge taking place just previous to the backfire. A glow differs from an arc in that it requires several hundred volts at the cathode for its maintenance. In rectifiers, the construction and vapor pressure are generally such that it is not possible to hold a self-maintaining glow with the available negative voltage which is impressed on the anode. However, with normal negative voltage on one anode and an arc playing to the other, current flows to the negative anode which does not differ essentially from a glow, except that it is not self-maintaining. Consequently both the glow and the non-self-maintaining discharge will be considered together as the back current discharge.

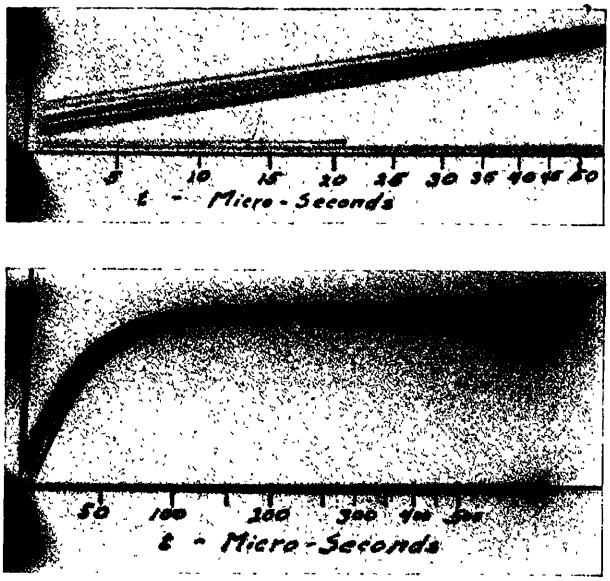


Fig. 4. Typical cathode-ray oscillograms showing time duration of backfire causes

A backfire consists in the sudden substitution of an arc for the normal back current discharge. Somehow, the conditions for the maintenance of the cathode of an arc must suddenly set themselves up. The conditions required at the cathode of an arc as predicted by present theory are such as should not occur spontaneously so far as the intrinsic characteristics of the back current discharge go. The conditions required at the cathode of an arc, according to present theories, call for either a very high temperature or a high current density.

With the low current density in the back current discharge, it is not possible to obtain sufficiently high temperature to produce an arc so long as the current is uniformly distributed over the anode. A sufficiently intense field at the cathode surface (10^6 volts per cm. or more) could initiate the cathode of an arc, but due to the high concentration of positive ions necessary such a field would require a current density of several thousand amperes per square centimeter. The current density in the back current discharge is only a few microamperes per square centimeter. The variation of current density over a very small area of surface might allow sufficiently high instantaneous densities, but such small areas must not be considered because the cathode of an arc is unstable if the current to it is less than 0.05 amperes.

Scrutiny of the back current discharge through the spectacles of present theories of the cathode of an arc fails to reveal the causes of backfire, provided the cathode surface be regarded as homogeneous. We must then consider the result of possible contaminations on the surface and flaws in the electrode material.

One type of backfire cause is suggested by tests made with a tube containing two graphite electrodes and equipped so that a small insulated tungsten wire could be caused to make or break contact with the cathode. Voltage was applied to the electrodes of the tube and when it was sufficient to form a stable glow, backfires could be produced by making or breaking contact on the cathode with the small insulated tungsten tip. The cause of the backfire is to be sought in the very high current density at the lost contact point. This very high density will result as the area common to the point and electrode shrinks to zero during separation.

Several backfire causes may now be given. A very obvious one is contacting mercury drops thrown from the cathode. Small conducting particles such as iron rust or scale may contact with the anode and cause backfire in the same way, and in this an argument for extreme cleanliness in rectifier assembly is found.

Particles may detach themselves from the anode itself. It is well known that the anode suffers a slow disintegration known as sputtering, due to the back current discharge. Although the sputtered particles may consist largely of individual molecules, it is believed that larger particles are also detached. The presence of impurities would tend to cause a more frequent detachment of larger particles.

From this discussion on possible backfire causes it would be expected that the magnitude of the back current is important. If the back current is large, then the particle size necessary to cause backfire may be smaller. Also, the sputtering of the electrode will be more rapid with a large back current, and large particles are more likely to be detached or loosened. Any means which reduce the back current to the electrode, such as grids, shields, etc., must also reduce the frequency of occurrence of backfire. Experience shows this to be the case.

Another cause of backfire suggested by Langmuir is the formation of insulating patches on the electrode with dielectric failure of the patch as it becomes charged by back current. These patches are made up of impurities, oxides, or what not, and because of the small amount of material in their make-up their development to large sizes will be a random occurrence. Other experimenters also have surmised the existence of such insulating layers.

DURATION OF BACKFIRE CAUSES

The random manner of occurrence of backfire as well as considerations of the preceding section make us believe that backfire causes involve only a small amount of matter. Since the amount of matter involved is very small, we should expect also that the time involved by backfire cause would be very small.

Cathode-ray oscillograph tests have been made to determine the time duration of backfire causes. A small metal tank rectifier was used, and continuous current was run to one anode and continuous negative voltage was applied to the other. A high resistance was placed in series with this anode so that in the advent of a backfire to it, a current too low for maintaining the cathode of an arc would flow. The cathode-ray oscillograph had a Norinder relay which was actuated by the backfire, and the voltage between tested anode and cathode was applied to the deflecting plates, typical oscillograms being shown in Fig. 4. The initial drop in voltage on the occurrence of a backfire does not appear because of a time-lag of three microseconds in the action of the Norinder relay. The time during which the voltage is very low is the time duration of the backfire cause. The finite rate of recovery of voltage after the backfire is due to electrostatic capacity of the potentiometer by which the oscillograph was connected to the rectifier. The duration of the backfire causes was usually less than five microseconds.

Losses in Mercury Rectifier Transformers

Improved methods of calculating and testing the losses in transformers for use with mercury arc rectifiers are now available. These methods greatly simplify the mathematics involved in loss calculations and make it possible to measure directly the losses of transformers independent of the rectifiers.

By
E. V. DeBLIEUX
Associate A. I. E. E.
General Elec. Co.,
Pittsfield, Mass.

DETERMINATION of the losses in transformers connected for use with mercury arc rectifiers involves difficulties not present in usual power transformers, due largely to the shape of the secondary current wave delivered to the rectifier. In the past, various tables have been published which give calculations of effective values of current and the losses in transformers in various rectifier connections. These calculations are based on the assumption that

---

From "Losses in Transformers for Use with Mercury Arc Rectifiers," (No. 31-70) presented at the North Eastern District meeting of the A. I. E. E., Rochester, N. Y., April 29-May 2, 1931.

the secondary current waves are rectangular in shape and that the effective resistance of the transformer windings is the same at all frequencies. However, calculations based on these assumptions may be considerably in error as the current wave contains a large number of harmonics which are influenced somewhat by the reactance of the circuits, and the effective resistance of transformer windings varies with the frequency. Using the d-c. resistance of the windings and the theoretical values of the harmonics as explained below, much more accurate calculations of transformer losses result.

A rectangular secondary current wave can be analyzed into a series of terms in which the amplitude of the nth harmonic is:

$$A_n = \frac{2J}{n\pi} \times \sin\frac{n\pi}{P} \tag{1}$$

in which J = magnitude of direct current

P = number of phases

The effect of the reactance of the circuit is to alter the assumed rectangular wave shape by sloping the sides of the wave, as a definite time is required for the current to rise to its full value at the beginning of the conduction period and fall to zero at the end. The effect is to reduce the magnitude of the harmonics in the current wave.

A formula has been developed for calculating the effective winding resistance in which

$$\text{Watts eddy current loss} = 0.86\,Y X^{1.875} \tag{2}$$

where

X = frequency

Y = the sum of the other factors which determine the eddy loss, and is constant for a given winding

The actual magnitude of the various harmonics in the primary and secondary current waves of a representative six-phase rectifier connection was measured, and from these readings and the corresponding winding resistances, the losses were calculated and found to be the same as would be obtained in the d-c. resistance of the windings, and the theoretical values of the harmonics as determined from equation (1) were used to determine the losses. This indicates that for the average circuit, the effect on the losses of the increase in resistance at the harmonic frequencies is approximately balanced by the effect of the reduction in magnitude of the harmonics due to the reactance of the circuits. These results hold with satisfactory accuracy for the other commonly used rectifier circuits.

The calculation of losses based on the d-c. resistance of the transformer windings and the theoretical values of current harmonics for rectangular secondary current waves has been recommended for the proposed A. I. E. E. Standards for Mercury Arc Rectifiers. This method eliminates involved mathematical calculations and factors based on design features. Also, the calculations may be checked by the purchaser and used to determine the safe size of cables for making connections.

TESTING METHODS

Three methods of testing are proposed for the three classes into which all of the commonly used rectifier connections fall. For all tests, rated sinusoidal current at rated frequency is held in the primary, and the secondary windings are short-circuited as follows for the various types of connections.

The six-phase multiple wye secondary connection of transformers is shown in Fig. 1. For this type of connection, the copper losses measured with one-half of the secondary windings of each phase short-circuited,

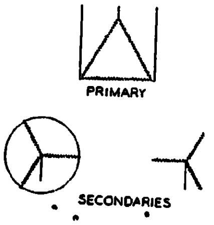
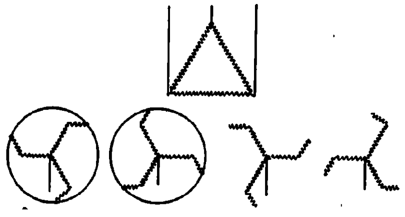
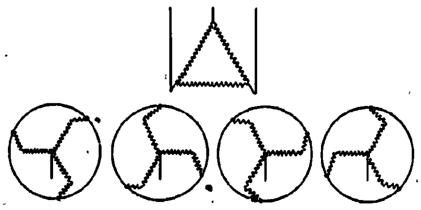


Fig. 1. Test connections for six-phase multiple wye transformers

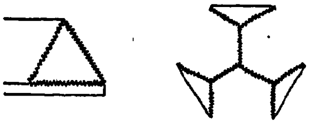


(a) TEST No. 1

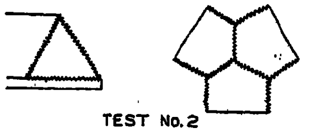


(b) TEST No. 2

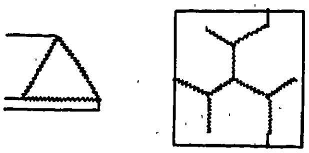
Fig. 2. (Left) Test connections for twelve-phase multiple wye transformers



TEST No. 1



TEST No. 2



TEST No. 3

Fig. 3. (Right) Test connections for six-phase forked wye transformers as indicated by the straight lines, equal the loss which would be obtained under rectifier operation.

For the twelve-phase multiple wye connection, two tests are made. The first is with one-half of the secondary coils of each phase short-circuited as shown in Fig. 2(**a**), and the second is with all of the secondary coils short-circuited as shown in Fig. 2(**b**). Denoting the losses measured in the two tests by L_1 and L_2 respectively, the copper losses which would be obtained under rectifier operation will be:

$$W_{cu} = 1.12\,L_1 - 0.12\,L_2 \tag{3}$$

For six-phase forked connections, three loss measurements are made with the secondary winding short-circuited as shown in Fig. 3. Denoting the loss measurements for the three tests by L_1, L_2, and L_3 respectively, the copper losses which would be obtained under rectifier operation will be:

$$W_{cu} = \frac{L_1 + 2\,L_2 + 3\,L_3}{6} \tag{4}$$

Since the voltage wave impressed on the transformer primary approximates a sine wave when the rectifier is fed from a system whose capacity is reasonably large, the iron loss should be measured in the same manner as for ordinary power transformers. It is therefore possible to test the main transformers of the various rectifier connections independently of the rectifiers, and determine with satisfactory accuracy, the losses in both copper and iron which would be obtained under rectifier operation.

Corona and Line Surges

Tests on an experimental transmission line show that from the standpoint of damping transient surges there is no advantage in operating the line at so high a voltage that the conductors will be in corona.

By
H. H. SKILLING
Associate A. I. E. E.
Stanford University
California

FREQUENTLY in technical literature the suggestion has been made that power-frequency corona would increase the damping of transmission-line surges. A recent repetition of this ideal, all unsubstantiated, led to the present investigation the results of which have shown that the presence of corona is of no value in this connection; its damping effect in any case is only slight and often is more harmful than helpful.

A surge on a line in service, if due to lightning, may have a voltage far exceeding the corona-forming voltage of the line; in such a case the chief attenuation will be due to corona. To explain further, the surge itself will ionize the air around the conductor and in so doing, the energy stored in the surge will diminish; the maximum voltage of the surge will decrease accordingly. Ionization will continue as the surge travels along the line as long as the voltage of the surge is above the corona limit; thereafter attenuation will be much slower, for the main damping influence will have lost its effect. This ionization is a real phenomenon, since the corona produced by a single impulse of extremely short duration may be seen clearly in the dark, and the noise that a surge makes as it passes may be heard quite as easily.

It is evident that a previous condition of ionization about the conductor due to overstress at power frequency would affect the rate of loss of energy from the impulse; but in what way may be found only by experiment. To determine the nature of this relationship, therefore, this investigation was undertaken.

TEST EQUIPMENT

Apparatus was devised by which traveling impulses with crests as high as 440-kv. could be sent along a 1,000-ft. line. For furnishing these high-voltage impulses, an adaptation of the "lightning generator" was used. A condenser charged by power-frequency current had its energy suddenly released by the breakdown of a sphere-gap, and as fast as the inductance of the condenser circuit permitted, the condenser voltage appeared between the sending end of the transmission line and ground. This voltage and current proportional to it sent along the line a wave the magnitude of which was increased with time, until a sphere-gap at the sending end of the line sparked to ground; the sending voltage then fell to zero almost immediately and remained negligible thereafter while the wave traveled out along the line and was measured. Ordinarily, the trip-gap was set to discharge the condenser at 375 kv. It was found convenient to chop the impulse by means of the

---

Written specially for ELECTRICAL ENGINEERING. Not published in pamphlet form.

gap at the sending end of the line at some value between 100 and 200 kv. The time required to build up such a voltage was about 0.05 microsec. The critical corona voltage of this 1,000-ft. line at 60 cycles was found to be about 30 kv. or 43 kv., crest value.

Voltages were measured at each end of the line and at several intermediate points by means of sphere-gaps. If the observer were far enough from the noise of the laboratory, an interesting supplementary comparison of impulse voltages was possible by listening to the sound that accompanied impulses of voltage higher than the critical corona value. A click somewhat like the noise made by dropping a pencil indicated that a wave had passed, and in passing had ionized the air; a second or so later would come the crash of the sphere-gaps in the laboratory; and perhaps between the two, the snap of the measuring sphere-gap. On a bright day the ear was more to be trusted than the eye in reporting events.

The rapid attenuation of surges when their voltages were higher than the corona-forming voltage of the line, and their slower attenuation near that voltage, is shown graphically in Fig. 1. The most evident disclosure of these curves is that the impulses, at whatever voltage they may be sent, are rapidly cut to a crest value between 25 and 50 kv. Thereafter attenuation is so slow that at the terminus of the 1,000-ft. line, it is difficult to distinguish between a wave that started with a crest of less than 100 kv. and another that started at more than 200 kv.

SURGES SUPERPOSED ON DIFFERENT 60-CYCLE LINE VOLTAGES

When the action of the impulses was moderately well understood and the technique of measurement was developed sufficiently to give assurance of significant results, the line was tested while in corona. The apparatus permitted the impulse voltage to be superposed suddenly on a steady 60-cycle voltage. The phase of the corona-voltage cycle at which the impulse was applied was definitely known, and in the first work the impulse "struck" at the instant of maximum 60-cycle voltage. The sending-end sphere-gap now did not measure the impulse voltage alone, but the sum of impulse and 60-cycle voltages, added when the polarities were the same and subtracted when they were opposite. The same is true of the measuring sphere-gap at intermediate points on the line.

These combined impulse and line-voltage measurements represent the values in which the engineer is interested, since the strongest impulse that may be propagated over a line is one which will not flash across a string of insulators when added to the line potential at that instant. Whether or not a surge still will be dangerous at some crucial point, as, for instance, at a transformer bank, depends upon whether at that point the insulation will fail under the combined action of normal line and impulse voltages. Hence, while the sphere-gap does not measure the impulse voltage directly, it does give an indication of danger. At the end of the line, reflection of the impulse adds to the danger; the resultant crest voltage at the terminus may be found by a simple computation, or it may be measured directly.

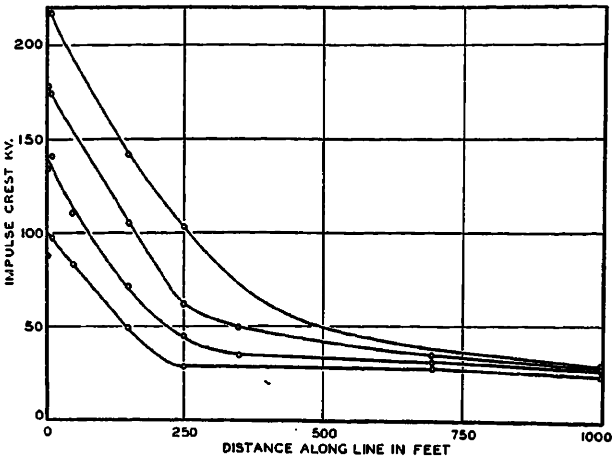


Fig. 1. Attenuation of transmission line surges. Note rapid reduction above the corona-forming voltage (30 kv.)

The presence of corona was found to make a measurable difference in the behavior of the high-voltage impulses. When the impulse was thrown on the line with the same polarity as the 60-cycle voltage, the rate of attenuation of the impulse was lessened to a marked degree, and the danger at any point was correspondingly great. When polarities were opposite, the 60-cycle voltage had less total effect; attenuation of the impulse was more rapid, which lessened the danger at any point along the line, but the danger due to reflection at the terminus was much greater.

The foregoing effects are shown in Fig. 2, where the crest voltage of a given impulse after traveling a certain distance is shown as a function of the 60-cycle line voltage. The lower pair of curves intersects the axis at a value corresponding to the 150-ft. point on the 133-kv. curve of Fig. 1. In like manner, the upper curves intersect the axis at a value corresponding to the 50-ft. point. These points on the two figures must therefore indicate the same impulse crest because they represent identical conditions. For the other points of Fig. 2 the impulse was superposed upon different 60-cycle line voltages. Points determined when the impulse and 60-cycle voltages were of the same polarity are marked with "plus" signs; points representing opposite polarity are indicated by "minus" signs.

SURGES APPLIED IN DIFFERENT PHASE RELATIONS

Apparently, attenuation of the impulse is not altered by line voltage unless the line voltage is high enough to produce corona, although this cannot be proved; however, the belief is supported by other tests in which the impulse was applied in various phase relations with respect to the corona-voltage cycle. With 40 kv. at 60 cycles applied, and with the gap at the sending end of the line retaining a fixed spacing, the moment of applying the impulse was shifted by 60-deg. steps. With the sending-end sphere-gap setting the same as used in obtaining the data for Fig. 2 (to give an impulse of 133 kv.) the impulse crest voltage without 60-cycle line voltage was measured at a distance of 150 ft. from the sending end; then 40 kv. was applied and the impulse was impressed at the same instant at which the 60-cycle voltage reached a maximum of the same polarity. These measurements were followed by another with two voltages of opposite polarity. These are shown in Fig. 3, the radius of the circle being a measure of the impulse voltage alone; the vector drawn upward (83 kv.) indicates the resultant impulse voltage when the polarities were the same, while the vector pointing downward (62 kv.) gives the resultant voltage when polarities were opposite. Similar measurements were made with the impulse applied 60 and 120 deg., respectively, after maximum line voltage first with one polarity and then with the opposite. Results of these tests are indicated also in Fig. 3.

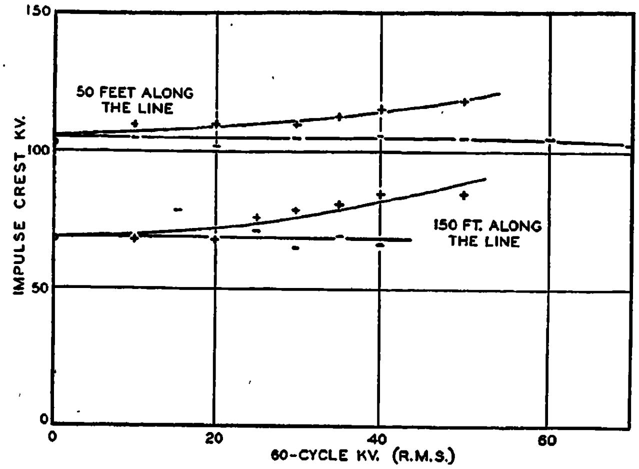


Fig. 2. Effect of different line voltages upon attenuation of 133-kv. surges

+ indicates surge and line voltage of same polarity
− indicates surge and line voltage of opposite polarity

For the first two cases (impulse voltage superposed upon a 60-cycle maximum of the same polarity and of opposite polarity, respectively) the expected change in rate of attenuation was observed; for the four intermediate phase positions there was no significant difference from attenuation without 60-cycle voltage.

TEST RESULTS ANALYZED

Space charge about the conductor when in corona seems to play an important role in aiding or impeding the attenuation of impulses. That the chief attenuation of the impulse is due to ionization is evident because (1) the impulse may be seen and heard and so must dissipate energy; (and 2) attenuation is rapid above the corona-forming voltage and slow below it. If 40-kv. power-frequency voltage be applied to a line that permits corona at 30 kv., there will be a zone about the conductor in which the potential gradient is the critical gradient of air (about 30 kv. per cm.); the gradient cannot be greater because air under a greater stress would ionize until the resulting space charge reduced the gradient to the critical value. (Since the times involved in 60-cycle changes of current and voltage are so vast compared to impulse times, the 60-cycle conditions existing at any moment may be considered fixed.) This cushioning action of the space charge makes possible the maintenance of a line voltage greater than the corona-forming voltage, for without such protection the air would continue to be broken down as fast as ionization by collision could take place; and were this the case, no reasonable amount of power could sustain a voltage substantially above that at which corona first appeared.

In the light of the foregoing, if an impulse voltage of the same polarity as the 60-cycle line voltage should occur, and if the 60-cycle voltage already has produced corona and hence protected itself by forming a space charge, it will be impossible for the impulse to attenuate by ionization to a voltage below the 60-cycle value. The cushioning effect that protects the 60-cycle voltage also will protect the impulse voltage. This is doubtless the reason that as soon as corona appears about the line, impulses are found to be attenuated more slowly if they are of the polarity of the line voltage. If they are of the opposite polarity, the space charge has the contrary effect; instead of lessening the gradient in the neighborhood of the wire as the impulse passes, it increases it. Presence of the space charge increases the electric field and thereby increases the energy loss, thus increasing the attenuation.

Without more quantitative information about energy loss from impulse voltages, it is impossible to predict the comparative efficacies of a given intensity of corona toward decreasing and increasing the attenuation of surges of similar and of opposite polarities. In the latter case, however, as expected and shown experimentally, the potential due to space charge is a smaller fraction of the impulse potential and will have a correspondingly lesser effect.

The wave shape of the impulse, that is, the function of time which describes the voltage at a point, also will influence the rate of attenuation of the impulse crest. An impulse shorter than 1 microsec. is considered fast, but ionization by collision is tremendously faster; hence a protecting space charge will be built up by the impulse itself as it travels along the line. If the wave is not sharp-crested but has a flat top, the latter part of the wave will be protected by space charge formed at the expense of the part preceding. While all of the wave eventually (if the line be long enough) will become reduced to the corona-forming voltage of the line, the front of the wave will lose energy most rapidly at first, and the crest voltage will diminish more slowly. No such action is possible in the case of a short wave, which rises quickly to a crest and as quickly falls. Space charge of enough intensity to protect the maximum voltage is formed only by the peak itself, and the wave immediately passes on to less ionized and unprotected sections. A long, flat wave, then, is less rapidly attenuated, and therefore is more dangerous than a short, sharp wave.

CONCLUSIONS

Work on attenuation of surges has been described in previous Institute publications (the most recent of these may be found in the July 1931 issue of ELECTRICAL ENGINEERING, pp. 478-502). Results of the present study are in such complete agreement with previous results that, for the most part, the conclusions reached may be quoted from the summary of one of the earlier investigations of Conwell and Fortescue, (A. I. E. E. TRANS., July 1930, p. 872) whose experimental work is of great interest in the light of the theory here presented:

> 1. "Considering crest voltage of the original surge and its attenuation, the attenuation is increased with crest voltage over the length of line used. The rate of increase in attenuation is much more rapid when the surge voltage exceeds the corona point of the line.
>
> 2. "Considering the relation between the length of wave and its attenuation, the short wave attenuates more rapidly than a long wave of equal crest voltage.
>
> 3. "Considering the effect of distance traveled on wave shape, with increased distance there seems to be an increased tendency to slope off the front of the wave and to increase the length of the tail. This change in form is more accentuated above the corona point."

To these now may be added another:

> 4. Considering the effect of power-frequency corona about the line, it will retard the attenuation of a surge of its own polarity, but will have little effect on a surge of opposite polarity.

The amount of attenuation is of great practical interest and there may be significance in a comparison of present results with those of Lee on the Wallenpaupack-Siegfried line. (TRANS. A. I. E. E., Vol. 48, p. 471.)

The line considered as the basis of this article was similar to the line considered by Lee, but reduced to one-tenth size; that is, the conductor considered in this article was about 10 per cent of the diameter of his and displayed corona at 28 kv. (r. m. s.) instead of at about 280 kv. The surges used were near 220 kv. while the lightning surge recorded on Lee's line started at 2,230 kv.

In becoming proportionately attenuated, his surge traveled 100 times as far as those mentioned in this article, or in the ratio of 10^2. These ratios were used in making up Table I: voltages of the line considered in this article are multiplied by 10; the distances by 100.

Included in the tabulation is a set of computed voltages that result from assuming that the energy lost (as the surge travels) is proportional to the voltage of the surge. This assumption is arbitrary, but agrees impressively with Lee's results and with those of this article as shown in the four curves, Fig. 1. Since energy is proportional to the square of voltage,

$$\frac{d}{dx} E^2 = - k (E - e)$$

where E is surge voltage, e is corona-forming voltage, k is an experimental constant, and x is distance along the line. The solution is

$$x = m [n - (E + e \log \epsilon (E - e))]$$

where m and n are constants involving k and the initial voltage. The computed voltages fit nicely into the tabulation, and differences can be explained as experimental error, line resistance, and (most important) change of wave-shape as the impulse travels.

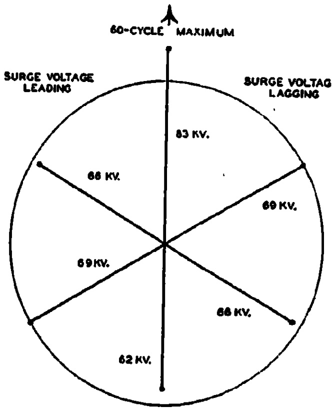


Fig. 3. Diagram showing surge-voltage measurements 150 ft. along the line with 133-kv. impulses applied in different phase relations with respect to the 60-cycle, 40-kv., line voltage

Radius of circle (68 kv.) indicates surge measurement with zero line voltage; arrow at top shows "in phase" position

These results imply that the "effective range" of a lightning surge is nearly proportional to the voltage of the surge, and to the corona-forming voltage of the line.

Table I—Comparative Surge Attenuation Data

Distance miles	0	5	10	15
Kilovolts				
Computed	2,230	1,180	560	410
Lee	2,230	1,080	680	320
Skilling	2,250	1,000	480	380

Dr. Harris J. Ryan and Dr. Joseph Carroll by guidance and aid have made possible the study leading to this paper.

Communication Plays its Part in Electric Power System Operation

Present day electric power systems, with their complex and far-flung interconnections, cover such large areas that the communication lines serving them have become almost as important as the power lines themselves. In the five articles on this and the following nine pages fundamental requirements of the electric utilities are outlined, and the communication schemes used by four typical operating companies are described.

ELECTRIC LIGHT AND POWER in all its perfection is not entirely independent of several other agencies of public service. Not the least of these is communication, which makes the light and power system the living organism it really is. Because the electric power system is everywhere, far flung in supply centers and activities, it is more dependent upon communication in the discharge of its obligations than are most other forms of business. This agency serves to coordinate the widely separated elements and thus plays a big part in unifying the operation of electric power systems. This is a necessary adjunct to the provision of satisfactory service to customers; for although a properly designed and constructed system, adequate tools, and able personnel, all are essential, yet no adequate service is rendered, and hence no revenue earned, until these elements are coordinated and unified.

This group of five articles is based upon five papers presented as a symposium at a session of the Institute's 1931 summer convention. They were prepared jointly by a total of six engineers of leading power companies, in collaboration with three communication engineers of the Bell telephone system, and therefore represent the joint efforts of those engineers most intimately connected with the needs of a power system and those having the best knowledge of modern developments in the communication field.

All five articles stress the importance of providing efficient and uninterrupted communication facilities for operating personnel. In most cases these facilities are provided by networks of interconnected privately owned and Bell system lines, although in one case carrier current furnishes the principal communicating medium. One article deals with a joint study between telephone and power company engineers, when the entire communication system of the power company was overhauled thereby effecting many improvements. Another article of the group describes the special communication facilities arranged by one company for handling customers' calls. Still another narrates in some detail how a special remote-metering system was installed, by which means continuous and practically automatic direction of load-scheduling activities was achieved.

The first article, which outlines the power company's principal requirements and suggests methods for meeting them, follows immediately.

Underlying Considerations of the Problem Outlined

By
R. N. CONWELL Fellow A. I. E. E. — Public Service Elec. & Gas Co., Newark, N. J.
G. M. KEENAN Fellow A. I. E. E. — Penn.-N. J. Interconnection, Hazleton, Pa.
C. F. CRAIG Member A. I. E. E. — American Tel. & Tel. Co., New York, N. Y.
E. C. BRIGGS Non-member — Ohio Bell Tel. Co. Cleveland, Ohio

EFFECTIVE COORDINATION of the activities of an electric utility necessitates the establishment of communication channels for the continuous flow of information into organization centers, and the prompt transmission of orders and suggestions from these centers to the points where action is taken. Voice communication appears to be especially adapted to meet these requirements, as is evidenced by the fact that about 85 per cent of the average electric utility's communication expense is for transmission of the spoken word.

From "Communication Services of Electric Utilities, Underlying Considerations" (No. 31-104) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

The work of an electric utility may be considered as being divided into the following three general classes:

1. Operating activities including dispatching, generating and substation operation, emergency line patrolling and repairs.
2. Customer service activities embracing all contacts between the utility and its customers.
3. Administrative activities including administrative sales and business functions as differentiated from service functions.

OPERATING ACTIVITIES

A typical organization chart for the handling of activities classed as "operation" is shown in Fig. 1. This indicates the communication channels usually necessary for the efficient flow of information between controlling centers and points where action originates. Communication facilities for such activities need to be:

1. Easy to operate and conveniently arranged.
2. Available at times when power facilities are in trouble.
3. Of such quality as to permit conversations to be carried on with ease.
4. Protected so as to be safe for use at all times including periods of system disturbances.
5. Of sufficient capacity so that under the *worst* emergency conditions no serious delays will be experienced in restoring electric service.

Heavy or important traffic requires the establishment of direct channels. Where continuous service must be provided, two or more independent paths are essential and these should be so routed that troubles on one will not affect the other.

Communication channels often are terminated at dispatching points in a cordless type of board where answering, ringing, and monitoring features are obtained by merely operating a key. This type of equipment appears to be suitable for use where no more than 50 channels are to be terminated, or where the required number of simultaneous through connections does not exceed five. Where more than these are involved, cord and plug boards usually are installed.

Teletypewriter apparatus is used to some extent in transmitting and recording routine information, such as meter readings and switching orders, and there is some probability that this equipment will provide a valuable supplement to the telephone in power-dispatching work.

Some electric utilities have considered it desirable to provide facilities for communication along the transmission line right-of-way. Both portable telephone equipment and permanent stations installed at convenient locations have been used for this purpose. The accessibility of the transmission line and the relative importance of maintaining uninterrupted power service over a particular route determines whether or not such facilities are necessary. Apparently each situation requires individual study to ascertain its particular requirements.

In effecting centralized control of a power system, the value of telemetering, remote indicating, and supervisory-control services is gaining rapid and wide recognition. Where long distances are involved, apparatus operated by direct current over separate channels or by means of impulses sent over narrow frequency channels appears to be the most economical. For shorter hauls, the cost of conductors usually is not prohibitive, and apparatus using separate wires for each metering or control service probably is the most economical and desirable. Since normally, large investments in power equipment are involved, and manual assistance cannot be obtained quickly at unattended stations, the conductors used for control purposes must give reliable service.

In some of the larger electric systems, arrangements are desired which will permit the sharing of frequency control by several generating plants, or possibly in the ultimate provide for station load distribution on an automatic basis in direct proportion to the relative costs of generation. In this connection it has been suggested that for the purpose of synchronizing frequency-controlling devices in generating plants, a constant-frequency supply might be furnished over communication channels. For this purpose, apparatus employing a quartz-crystal oscillator in conjunction with vacuum-tube circuits is available in laboratory form; a frequency stability of approximately one part in ten million or about three seconds in one year is provided. Tests to determine the value of this constant-frequency supply in electric utility operation are being considered.

CUSTOMER SERVICE ACTIVITIES

A vital factor in supplying satisfactory electric service is the provision of convenient means for the customer to convey to the utility company his impressions and

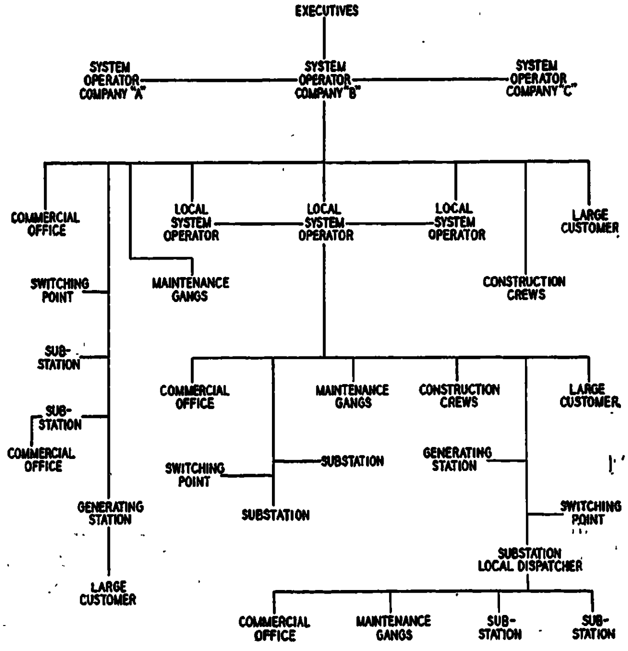


Fig. 1. Typical communication channels for perating activities of an electric utility

reactions regarding his electric service. Since a large majority of such contacts is made by telephone, electric utilities generally have recognized that customers calling by telephone should be handled as intelligently and as courteously as though calling in person.

Experience indicates the desirability of establishing an organization specially trained and assigned exclusively to dealing with customers over the telephone. Under this plan, direct observations can be made to determine which practises are most effective in building up good-will among the customers. Where centralized customer-service bureaus are established, communication channels are necessary between the bureau and the various departments in the company so that the attendants may obtain readily any information necessary for transacting business with customers. Usually the work of the bureau is simplified as much as possible; this may be done by providing a centralized file of customer records, by short-cut methods of handling customer orders, and by the convenient arrangement of telephone facilities.

ADMINISTRATIVE ACTIVITIES

Included in this group are executive, legal, engineering, and accounting matters together with certain features of operating work where speed of action is not the governing factor. The type and volume of administrative activity handled by telephone generally necessitates extensive circuit and equipment arrangements. These communication facilities usually are provided by the telephone companies. It is important that the electric utilities make their objectives clear so that the communication arrangements provided by the telephone companies will accomplish the desired results.

Essential requirements in communication channels for administrative traffic are no different than those for similar traffic in other lines of business. When the volume is sufficient, channels are leased for full-time use. Arrangements may be made with the telephone company also for short-period talking channels to be set up at certain specified hours of the day. Where traffic is light, ordinary public-message channels usually provide satisfactory service.

Where quick transmission of letters, orders, accounting matters, or other administrative affairs, is necessary, and a written record is desired, teletypewriter service has been found to be of particular value.

METHODS OF PROVIDING COMMUNICATION CHANNELS

Cable and open wire. Most of the communication channels used by electric utilities consist of cable and open-wire lines. Cable is relatively free from trouble during storms and is considered a desirable type of facility while from the standpoint of service continuity, open-wire channels are somewhat less desirable. Where open-wire circuits only are in use, enough channels often are available over regular or alternate routes to insure the desired reliability. Where necessary, extra guying, short spacing of poles, and similar measures are employed to strengthen such lines. There seems to be a growing disinclination, however, to rely upon open-wire facilities routed along the same right-of-way with power lines on which service is to be protected.

Carrier-current telephone apparatus. In a number of instances during storm breaks, power-line carrier-current equipment has provided the only means of communication available, and it is considered generally to be a reliable form of service. There appears to be a definite but somewhat limited application for this type of communication over long hauls where generating plants and substations in remote and sparsely settled locations must be reached. In such situations the cost of providing suitable cable or open-wire facilities may be prohibitive.

Variation in quality and volume of transmission often is experienced with carrier current due to the fact that the characteristics of the power network used as the transmitting medium are affected by switching or circuit changes. Difficulty also has been experienced in connecting the apparatus to two-wire circuits. Opinions as to the value of this type of equipment differ, and in order to arrive at satisfactory conclusions regarding the extent to which it logically may be employed, further experience is necessary.

Radio. In providing back-up service for regular communication facilities some use has been made of radio, but the cost of securing the desired reliability and restrictions as to operation have prevented any extensive use of this type of communication.

BASIC COMMUNICATION PLAN NEEDED

For most efficient results, maximum use should be made of all communication facilities, a satisfactory grade of service should be available for immediate use at the principal operating points, and future needs should be cared for slightly in advance of actual demand and without replacement of any large part of existing facilities. These objectives cannot be met economically without establishing a basic communication plan for the electric supply system as a whole, developed along consistent lines.

Extensive interchange of power between electric utilities and frequent consolidation of operating properties is emphasizing the need for some degree of uniformity in communication arrangements. Also traffic loads and operating contingencies usually can be cared for with a greater margin of safety and less expense where all telephone services and facilities are unified and operated as one system. Convenient switching arrangements accordingly have been developed to allow the operating department to seize quickly and hold any desired circuits for an indefinite period of time. These arrangements permit the exclusive use of circuits by the operating personnel whenever in their opinion such use is necessary, and would seem to provide in effect the equivalent of an exclusive communication network.

In a number of instances studies have indicated that best results could be secured through the connection of the electric utility's privately owned communication system to the facilities furnished by the telephone company. Interconnections of this nature enable the electric utility to eliminate all useless duplication of circuits and equipment, to obtain a broader use of privately owned plant, and to retire such plant investment in an orderly fashion.

Growth of the electric utility industry is extremely rapid. Activities of operating companies are broadening in scope continually as the areas served increase in size and customer demands become heavier and more exacting. It is important that the activities of electric utilities be studied constantly to determine how communication facilities can be used to greater advantage and to anticipate requirements so that the necessary service will be available when required. Consideration along these lines will assist to a marked degree in the attainment of that which utilities are striving for—continual improvement in customer service.

Communication in the Niagara Hudson System

By
E. S. BUNDY
Member A. I. E. E.

Buffalo (N. Y.) Niagara & Eastern Power Corp.

THE WESTERN DIVISION of the Niagara Hudson System which serves an area in New York State approximately 250 mi. long and 100 mi. wide has developed a coordinated communication plan including both privately owned and leased lines supplemented by carrier current. In the development of this system, engineers of the New York Telephone Company have worked in cooperation with the power company's operating and executive staffs to develop a flexible, dependable, and adequate communication network.

One of the outstanding features of this system is the manner in which customer calls are handled. These do not go to the general switchboard but are routed directly to a specially equipped order receiving table where a specially trained personnel handle them directly without irritating department-to-department transfers.

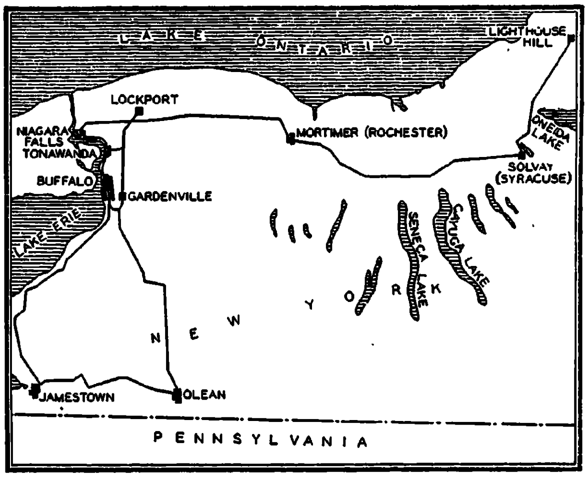


Fig. 2. Transmission system of the Buffalo, Niagara & Eastern Power Corporation (western division) showing principal switching points

Lines leased from the telephone company for full 24-hr. use connect the load supervisor (at Buffalo) with the Buffalo steam stations, the Niagara Falls hydro station, and the Lockport switching station, these being key points on the transmission system. Three of these leased lines provide remote-metering facilities for indicating at a glance the total load on the 60- and 25-cycle steam stations in Buffalo, and the hydro station in Niagara Falls, these being the three main power sources for the western division. Provision is made also for reaching Mortimer, Lyons, Solvay, and Syracuse through Lockport, and Gardenville, Jamestown, and Olean through the automatic dial-switching equipment in the Buffalo office. (See Fig. 2.)

In addition to the foregoing facilities the four main switching stations of the division, Niagara Falls, Lockport, Gardenville, and the Buffalo steam stations, are tied together directly by leased lines, so that district load supervisors may hold from two- to four-party conversations for discussing the proper execution of orders. The load supervisor's office is equipped with cordless turrets (similar to that shown in Fig. 5) for the interconnection of telephone lines of all types and for the quick and easy answering and switching of calls.

Among the many advantages of leased lines are these; that they do not follow the transmission right-of-way, and where two leased lines are in use between important points, they follow different routes. Both of these features enhance the inherent reliability of these lines. In addition, during storms the first responsibility of the power company is to maintain the transmission lines; where leased lines are used, the telephone company handles the communication problem. The possibility of storm failure is reduced to a

---

From "Communication in the Western Division of the Niagara Hudson System" (No. 31-111) presented at the A. I. E. E. summer convention, Asheville, N. C., Jun 22-26, 1931.

minimum, however, because practically all leased lines are run in cables.

Although the company is a large user of leased lines, thus eliminating maintenance worries and profiting from the advice of experts in the field of communication, privately owned lines belonging to predecessors are used where they were found to be in good condition. These private lines are interconnected with the leased lines, suitable protective equipment being installed at the connecting points. Such an arrangement provides great flexibility in the communication system and makes possible the use of previous investment in privately owned lines.

Eight carrier-current stations are maintained at main switching points, but under normal conditions these are not used to any great extent where leased lines are available; however, to make sure that it is in operating condition for possible emergency use each set is tested daily.

INTERDEPARTMENTAL COMMUNICATION

In the company's branch exchange in Buffalo, and in several of the district offices, machine switching equipment has been installed. Calls from one department to another are dialed by the calling party directly, as are calls to the telephone company's central office. Operators on general office switchboards thus handle only incoming calls to that office. As a result, calls have been speeded up and in the Buffalo office the staff of operators has been reduced from nine to five, despite the fact that telephones served have increased in number from 189 to 325, with a corresponding increase in the amount of traffic handled.

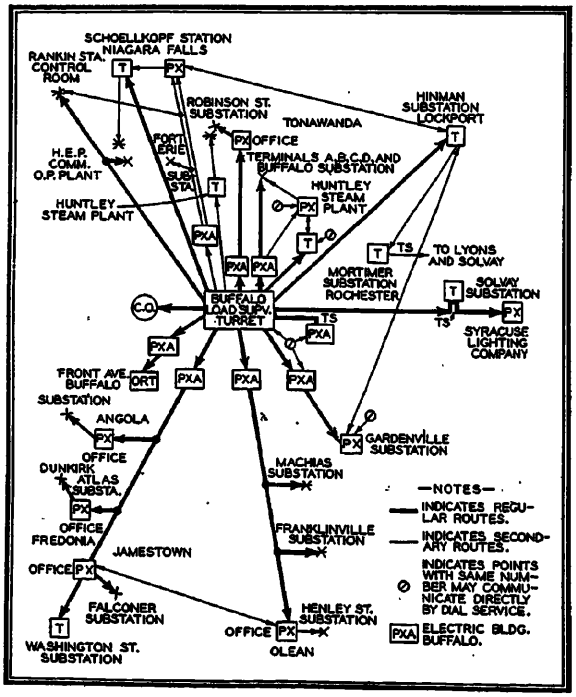


Fig. 3. Diagram of load dispatcher's communication facilities

In some of the smaller district offices, normal traffic will not justify the installation of machine switching equipment but service to customers, especially during times of trouble, will. In such cases operating men must be able to reach all parts of the system without interference from incoming calls. Where the dial system has been installed, the operating men can call the stations directly; a flood of customer calls thus does not interfere with their activities, and, at the same time, the telephone operator can devote undivided attention to customers.

CUSTOMERS' CALLS

Telephone calls from customers do not go to the general office switchboards but are routed directly to specially equipped order receiving tables. In the Buffalo office eighteen special trunks connect from the telephone company's central office to this table, and these are arranged in such a way that any call may be taken at any one of three different positions, there being a total of fourteen positions at the table.

Specially trained young women handle all types of these customer calls, which are largely reports of trouble, requests for service connections or disconnections, complaints, and requests for information. All positions at the table are connected by direct lines with the meter and trouble departments. Also ten tie lines connect the table with the company's machine switching equipment, thus allowing for connections to any one of the 325 extensions on this branch exchange.

Numbers are so listed in the telephone directory that customers rarely call the general office switchboard by mistake. When these errors do occur, however, they are connected by the telephone operator to the order receiving table without inconvenience and without being required to make a second explanation of what they want. Customers' calls which come to the service department but which really should go to the general office switchboard receive the same attention.

To maintain proper supervision over the telephone contacts with customers and at the same time bring about improvements in telephone usage, a monitor set has been installed so that observers may listen in on all conversations through the company's private branch exchange. Conversations are taken down verbatim and subsequently discussed at departmental meetings.

Five telephone typewriters connect this department with the meter and trouble departments located in the service building two miles distant. These teletypewriters are operated over leased lines and provide filled-in order forms on both the sending and receiving machines, the entire operation being completed within a very few minutes after the customer's request has been received.

Telephone contact with customers thus has been centralized in a well-trained department with great improvement in public relations. The personnel of the department follows through each request to completion; and moreover the customer is not transferred, disappointed, or kept waiting.

SUMMARY

The principal features of special interest in the communication scheme of this system briefly are that:

1. The company relies largely upon advice of the telephone company's engineers, believing that they are the best authorities available in the communication field.
2. Leased lined are used chiefly, thus freeing the company of maintenance problems and providing better and more dependable voice transmission.
3. Wherever practicable, automatic equipment is used for speedier service.
4. Both leased and private lines are interconnected for maximum flexibility.
5. In the interest of better public relations, great care has been taken to insure that customers' calls receive the best and most courteous service.

Joint Study Improves Communication Facilities

By
C. A. BOOKER New England Pwr. Assn., Boston, Mass.

M. E. CLARK New England Tel. & Tel. Co., Boston, Mass.

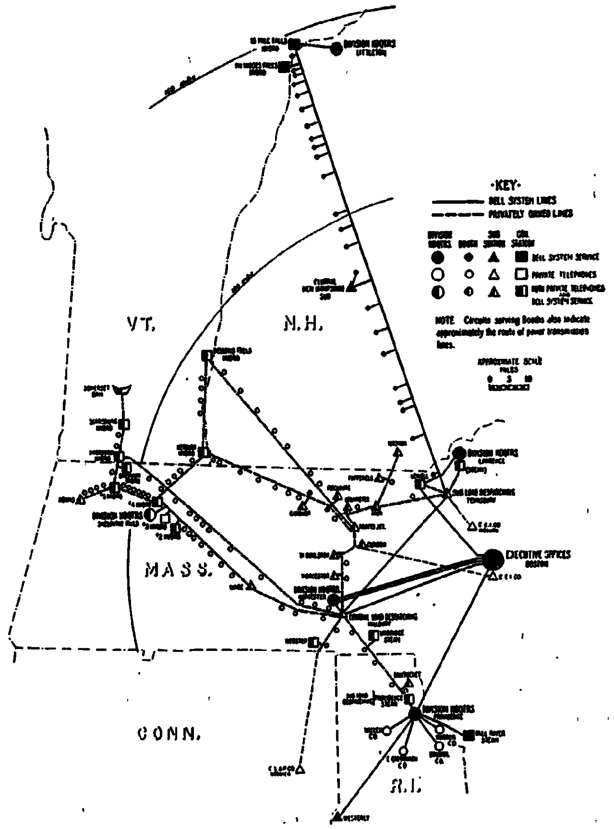


Fig. 4. Principal communication circuits of the New England Power Association

A LARGE GROUP of interconnected wholesale and retail electric companies are operated by the New England Power Association in a highly developed industrial area covering parts of five states. Energy is generated at eleven major hydro stations on the Connecticut and Deerfield rivers, whence it is transmitted over a high-voltage network to the load centers in central and eastern Massachusetts and Rhode Island; here interconnections are made with several large steam generating plants. To insure maximum economy in operation, a centralized control over all producing and distributing units is necessary.

To maintain this centralized plan of control, a network of communication circuits consisting of lines leased from the Bell telephone system interconnected with privately-owned lines has been set up (see Fig. 4). This arrangement represents the results of a joint study by executives of the telephone and power companies, instituted several years ago when the need for a more closely coordinated communication system was felt.

Operating control over the entire system is exercised by the load-dispatching department. This department has jurisdiction over power production, apparatus, safety work, the scheduling of future operations, and arrangements for power interchange with other systems. Control operations are planned from an extensive system of hourly reports received from each producing and distributing unit. Most of this work is carried on over approximately 600 mi. of privately owned telephone circuits.

For customer service and other commercial relations, regular subscriber service of the Bell system is used. Where the volume of traffic warrants it, P. B. X. (private branch exchange) switchboards are installed. Telephone extensions to the customers' service department are so arranged that all calls involving service on anything from flat irons to electric refrigerators are received at one place. This is done in order that such calls may receive prompt and sympathetic treatment without irritating transfers from one department to another.

Administrative activities of all units in the entire system are carried on from central offices located at Boston over a coordinated network of leased lines. By

---

From "Cooperative Study of Power System Communication" (No. 31-113) presented at the A. I. E. E. summer convention, Asheville, N. C., Jun 22-26, 1931.

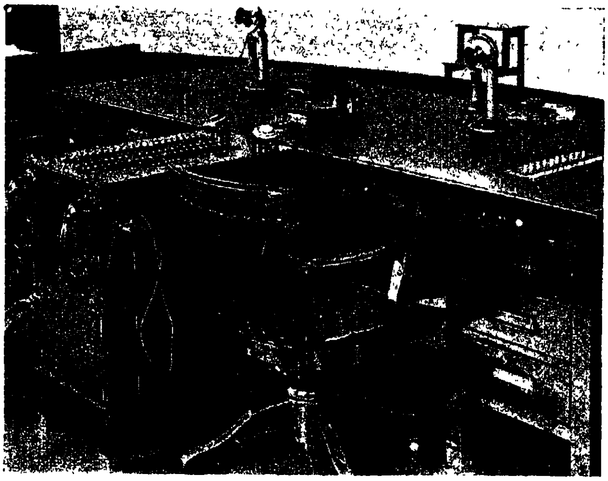


Fig. 5. Dispatcher's desk showing location of cordless turret wherein all communication lines terminate

interconnections at territorial office switchboards, economical and speedy communication with every part of the system is provided.

JOINT STUDY CONDUCTED

The joint study between telephone and power company engineers mentioned previously was instigated in 1929, when, with the consolidation of all of the principal offices at Boston, it became urgent to improve all types of service. In this study the entire communication problem was analyzed by parties having a thorough knowledge of modern telephone equipment, in cooperation with those most familiar with the operation and needs of the power system. Activities of the group conducting the joint study may be classified briefly as (1) a complete survey of existing communication facilities and usage; (2) the determination of present and future requirements; and (3) the analysis of these requirements to determine what alterations or additions are needed.

RESULTS OF STUDY

Although the survey has not been completed, many improvements in communication service already have resulted. Private branch exchanges serving local areas, districts, and divisions have been rearranged and in some cases modified to meet more fully the requirements of the territory served. In some instances these modifications have been effected at an actual saving in cost. Some of the more important findings of the joint study are outlined in some detail in the paragraphs which follow.

One of the earlier determinations of the joint study was the need for better call-handling facilities in the load dispatcher's office. It was desired to provide access to all lines but with a minimum of switching by the dispatcher. This was accomplished by the use of cordless turrets placed adjacent to the dispatcher's desk (see Fig. 5). The circuits were arranged so that the P. B. X. operator handles all calls not intended for the dispatcher, but at the same time the dispatchers have full control of all lines for possible emergency use. Provision is made for visible as well as audible indication of incoming calls.

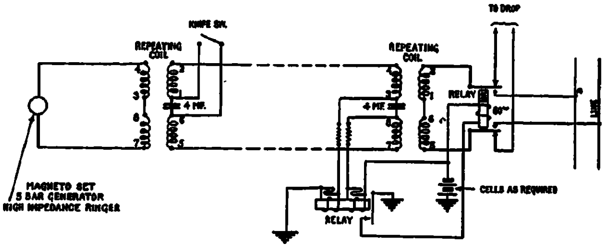


Fig. 6. Schematic diagram of patrolman's spur lines along the Tewksbury-Fifteen Mil Falls transmission line

Another noteworthy result of the study is found in the reduction of noise on the company's privately owned lines. This was brought about by a complete field inspection and survey followed by the correction of transposition unbalances, clearing up of tree troubles, and the replacement of broken insulators and bad splices, wherever the survey indicated that these steps were necessary.

Advantages of the joint survey for determining future requirements were realized in the planning of communication facilities for the Fifteen Mile Falls hydro development in 1929. The final arrangements for this particular case consisted of leasing a line from the Bell system from Tewksbury to Fifteen Mile Falls (see Fig. 4) with a permanently bridged tap to the central New Hampshire substation. This decision was reached when it was considered that (1) in case of trouble the telephone company could furnish duplicate paths, (2) within a few years the entire line would be of so-called sleet-proof construction, and (3) that the annual cost to the power company would be lower than the cost of constructing and maintaining a privately owned line.

A novel feature of this particular line is the arrangement for communication facilities from patrol booths along the line (see Fig. 6). These facilities are provided by spur lines having an average length of about five miles, and extending from the booths to central offices through which the main line passes. These extensions normally are disconnected from the trunk circuit, but each line may be connected by simply closing a switch in the booth, the actual connection being made by a relay. Provision also is made to enable the patrol station to signal the operator at the telephone company's central office in case exchange or toll service is desired.

Special arrangements have been made by the telephone company for routine and emergency maintenance of this line, and if for any reason the leased line is out of order preferential treatment is guaranteed for dispatching business over regular toll circuits.

CONCLUSIONS

Although the communication requirements of the New England Power Association have presented some unusual problems, joint consideration of these requirements has resulted in a satisfactory communication system. The provision of adequate communication service is essential to the operation of the power company, and in order that this may be accomplished economically and with minimum duplication of effort, as the requirements change in the future it is planned to continue the joint survey work.

Communication in a Metropolitan System

By
P. B. JUHNKE
Member A. I. E. E.
Commonwealth Edison Company, Chicago

COMMUNICATION facilities for the Commonwealth Edison Company system (Chicago) the fixed plant of which is scattered over the entire city, include 19 telephone switchboards, and a total of about 2,600 telephone stations. The main switchboard, together with seven sub-boards, are located in the Edison Building in the downtown section of the city. Of particular interest are the facilities employed in the technical direction and supervision over operating activities.

Operation of this system is carried on like most other large systems by a specially trained technical group located in a central load-dispatching office. Direct private-wire connections are provided between this office and all generating and distributing stations and the majority of substations. Dispatching activities are subdivided into three sections, two of them dealing with the usual routine of load dispatching, and each having supervision over a certain part of the system. The third division known as the load-control section is of relatively recent origin and is charged with supervision over the supply of power from the different generating centers. This third section also has supervision over the 66- and 132-kv. tie-line elements between stations. These supervisory activities embrace not only generating stations and tie lines within city limits but also interconnections with, and supply from, generating stations outside of the city. Direct telephone communication is provided from the load-control group's own two-position board to all generating stations and 66-kv. switching centers.

Before the organization of the load-control section, its functions were carried on by the load dispatchers making this work part of their regular duties. When only two or three generating stations were in operation the load-division problem was fairly simple, but as other stations were added to the system, each in turn more efficient than its predecessor, this problem became more complex. Accordingly a system was set up whereby the load distribution was adjusted hourly on the basis of corresponding hourly load readings from the individual stations. Although this scheme worked out very well, it required almost continuous readings to distribute the load properly, and as more generating stations were added to the system it became quite a laborious process.

LOAD-TOTALIZING SCHEME

As an outcome of the hourly system of load apportionment, a load-totalizer was developed to collect the individual station loads in the dispatcher's office, the power reading being transmitted by remote metering over telephone wires. Although this original arrangement represented a definite step forward, continuous direction on the part of the dispatching personnel was required to maintain the proper load apportionment. Accordingly, this original scheme was followed by further development known as the load-totalizing scheme with reverse indication. In this latter plan the totalization indications effected in the load dispatcher's office are transmitted back to the individual stations. With the aid of these continuous total-system-load readings and previously prepared load charts, each operator can hold the load on his particular station to its proper value at all times.

REMOTE-METERING SYSTEM

The remote-metering system used in totalizing the station loads has been described in a previous publication. ("Budget-Plant Load Dispatching," by P. B. Juhnke and L. N. Moore, *Electrical World*, Vol. 89, pp. 1317-1320.) However, a number of improvements recently have been made in this apparatus. Instead of balancing the effect of the impulses by mechanical means as done originally, some of the recorders have been changed to operate on a resistance bridge arrange-

---

From "Communication Facilities of a Metropolitan Power System" (No. 31-98) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

ment. With this improvement it is not necessary to install all of the meter elements on the load dispatcher's board. Several load recorders thus can be mounted in a relatively small space so as to be easily read by the personnel at the load-control board. Since all of the charts are controlled by the same synchronous motor, records may be compared directly and all meters will record for the correct time.

Metallic telephone circuits are used exclusively in this remote-metering scheme as installed by the Commonwealth Edison Company. However, the impulses (into which the load readings are translated) can be transmitted by means of carrier current,—a feature which materially enhances the usefulness of the system, especially for metering distant stations.

This type of installation is believed by the author to make possible the most intelligent operation of a large interconnected system. The task of directing load-scheduling activities is continuous and practically automatic. In addition, the economies gained in plant operation of a system of moderate geographic extent more than warrant the cost of the equipment and incidental telephone line rental.

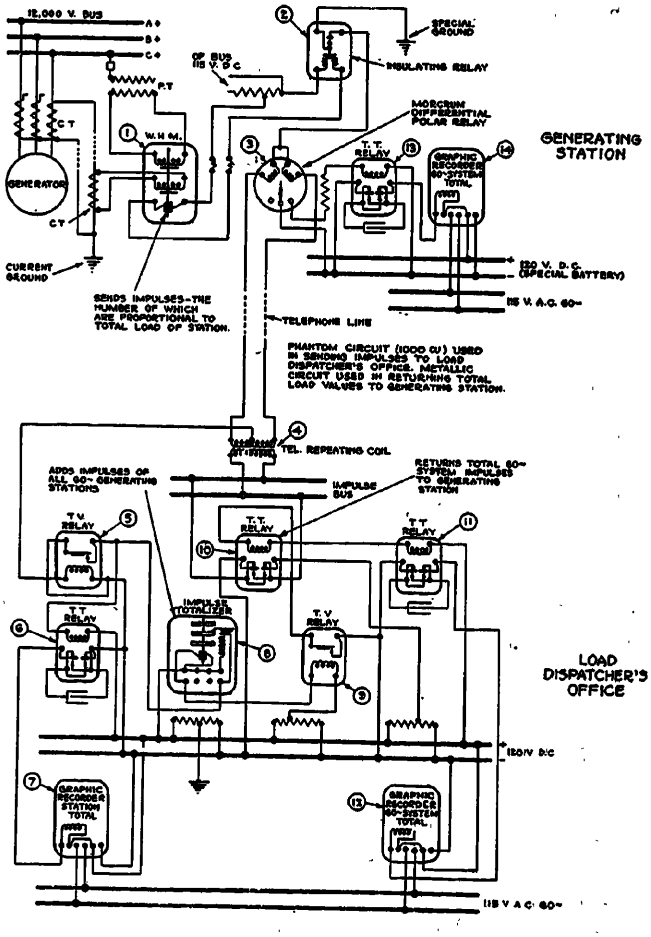

12,000 V. BUS
A
B
C
GENERATOR
CT
CT
CURRENT GROUND
DC BUS 115 V. D C
P.T
①
W.H.M.
②
SPECIAL GROUND
INSULATING RELAY
③
MORCRUM DIFFERENTIAL POLAR RELAY
T.T. RELAY
⑬
GRAPHIC RECORDER 60~SYSTEM TOTAL
⑭
GENERATING STATION
120 V. D.C. (SPECIAL BATTERY)
115 V. A.C. 60~
SENDS IMPULSES—THE NUMBER OF WHICH ARE PROPORTIONAL TO TOTAL LOAD OF STATION.
TELEPHONE LINE
PHANTOM CIRCUIT (1000 ω) USED IN SENDING IMPULSES TO LOAD DISPATCHER'S OFFICE. METALLIC CIRCUIT USED IN RETURNING TOTAL LOAD VALUES TO GENERATING STATION.
④
TEL. REPEATING COIL
ADDS IMPULSES OF ALL 60~ GENERATING STATIONS
IMPULSE BUS
RETURNS TOTAL 60~ SYSTEM IMPULSES TO GENERATING STATION
T.V. RELAY
⑤
T.T. RELAY
⑩
T.T. RELAY
⑪
T.T. RELAY
⑥
IMPULSE TOTALIZER
⑧
T.V. RELAY
⑨
LOAD DISPATCHER'S OFFICE
120 V D.C
⑦
GRAPHIC RECORDER STATION TOTAL
⑫
GRAPHIC RECORDER 60~SYSTEM TOTAL
115 V A.C. 60~

Fig. 7. Remote metering system used for load totalizing by the Commonwealth Edison Company

Carrier Communication Economical for Long Distances

By

E. C. STEWART

Arkansas Pwr. & Lt. Co., Pine Bluff

CARRIER-CURRENT telephony supplies most of the communication needs for the Arkansas-Louisiana-Mississippi interconnected system comprising a total of approximately 1,800 mi. of 110-kv. lines. Operating supervision for the entire interconnected network is centered in the load-dispatcher's office at the Woodward switching station near Pine Bluff (Ark.) except for the southern portion which is handled from the Jackson (Miss.) office. (See Fig. 8.)

Upon completion of Remmel Dam near Malvern (Ark.) in the latter part of 1924, and the connection of the hydro plant at that location with Pine Bluff and Little Rock, an urgent need for fast and reliable communication was felt. The construction of a new communication line along the power line right-of-way was contemplated but it was believed to represent an unwarranted expense when the reliability of such a line was compared with that of the power line itself. Finally, after a careful consideration of these and other factors involved, carrier-current equipment was installed during the early part of 1925. Results with this first installation were so satisfactory that in 1926 when the communication service had to be extended to Sterlington (La.) additional carrier-current equipment was used for this purpose.

Further extensions of this transmission system have necessitated corresponding extensions in the communication system; these likewise have consisted of carrier-current applications. At the present time a total of eleven carrier-current installations has been made located as shown in Fig. 8. In most cases comparatively long transmitting distances are involved, the longest of these being the 459-mi. stretch from Pine Bluff to Gretna.

To prevent the carrier waves from being dissipated on portions of the transmission system not used for communication purposes, by-passing and frequency-blocking equipment is installed at some locations. Arrangement of this equipment as installed at the Woodward switching station is shown in Fig. 9. Two transmitting sets are in use at that station so that additional blocking had to be employed.

Carrier-current equipment of the Southwestern Gas & Electric Company, shown also in Fig. 8, operates on a

---

From "Communication on the Arkansas-Louisiana-Mississippi Interconnected System" (No. 31-116) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

frequency channel different from that of the Arkansas-Louisiana-Mississippi interconnection, but so far no frequency blocking has been found necessary between the two systems. For communication between the two systems separate receivers are employed at Pine Bluff and Shreveport.

With the exception of the Remmel Dam set, where antennas are used, all coupling between the carrier-current apparatus and the transmission lines is by means of capacitors. No failures have occurred on any of these units during the past two years, which is the maximum length of time that any of them have been installed.

OPERATION

The carrier-current installations on the interconnected system, supplemented by the use of toll service and one or two leased lines, are primarily for use by the dispatcher. A certain amount of business traffic is handled, however, outside of rush periods, and is relayed by the dispatchers to the parties addressed.

Records of the number of messages transmitted show that at the Woodward station the average number of carrier-current equipment operations per month is about 4,800 for both installations. A three months' study of the time of usage indicates that the average message length is only 1¼ min.

Direct communication between outlying stations on the interconnected system has not been allowed because there is little advantage in this from a system operating standpoint. Calls of this nature are handled through the Pine Bluff dispatcher, his office having been made a "central" for that purpose. To complete such a call, it is necessary for the substation instigating the call to signal the Pine Bluff dispatcher from whence the call is dialed to the station desired. Completion of the call is evidenced by the automatic starting up of the transmitter at the station called.

Up to the present time carrier current has not been provided along the lines for the use of patrol or maintenance men. Routine patrolling reports are not turned in by telephone except under emergency conditions when the nearest available form of communication is utilized. During the past three or four years whenever weather conditions have permitted emergency patrolling has been made by means of airplane. Reports of

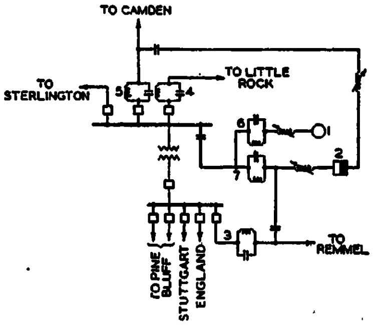


Fig. 9. Coupling, tuning, and blocking devices installed at the Woodward station

1 and 2. Carrier-current transmitters
3, 4 and 5. Resonant chokes
6 and 7. Traps to prevent interference between sets

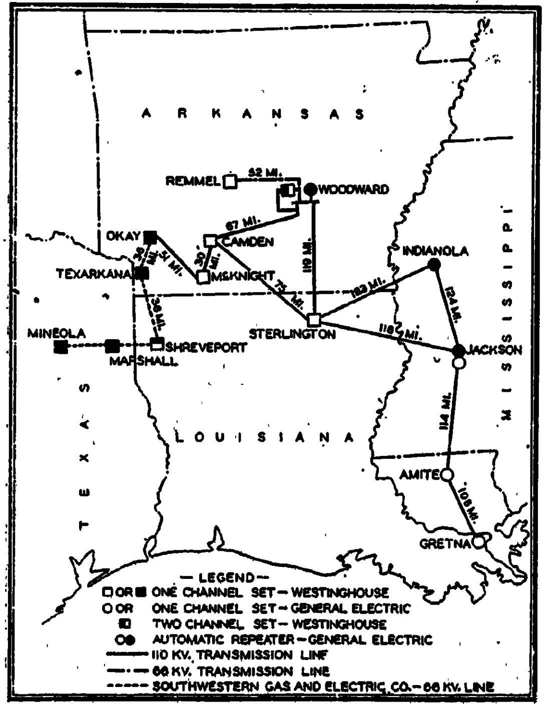


Fig. [illegible]. Location of carrier-current sets on the Arkansas-Louisiana-Mississippi interconnected system

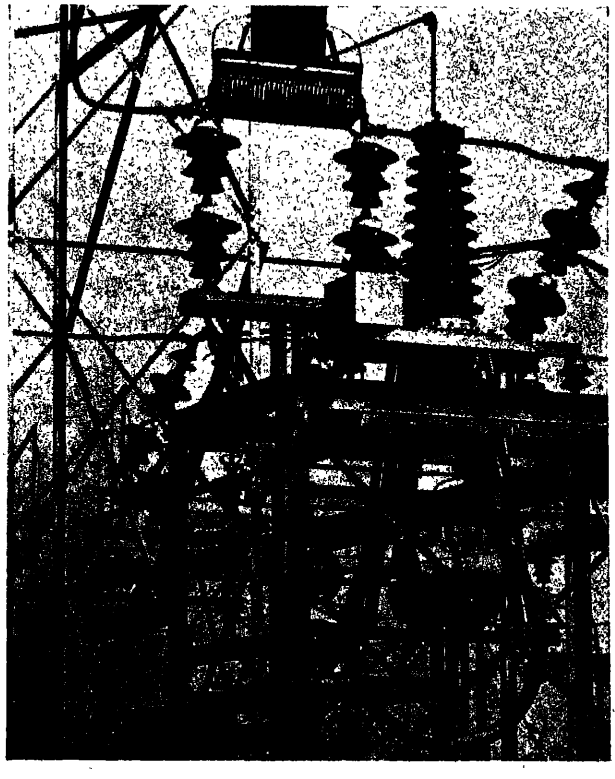


Fig. 10. Typical cable-type coupling capacitor and trap installation

observations made in this way usually are dropped in pasteboard containers to a substation operator, who relays the information to the dispatcher. In these reports, exact structure numbers are given in order to fix definitely the location of the trouble. Identification is made by means of distinguishing markers on top of key structures which are readily visible from the plane.

RELIABILITY

A number of instances are on record showing that the carrier-current type of communication affords an extremely reliable type of service. Several times during storms when other means of communication were disabled, uninterrupted service was maintained over the carrier-current circuits. One instance of particular note occurred during the months of April and May, 1927, while the Mississippi Valley was engulfed in the great flood of that period. For many days carrier current provided the only means of communication to the Sterlington station.

The Way to Progress and Prosperity

Equitable taxes and fair distribution of the cost of government in place of the present unfair indirect bonus system is urged as a vital first step toward cultural progress and public welfare. This is the third article of The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
C. E. GRUNSKY President, American Engineering Council

UNEMPLOYMENT is the most striking symptom of recurrent hard times. Attribute this, if you wish, to the fact that one man now produces what three or more could produce a few years ago, but remember that demand in kind and quantity also has increased vastly. Depressions would be recurrent even if the typewriter, the harvester, and the automobile had not been invented. However, the relative number of basic producers has been materially decreased and, in consequence, increasing numbers must be provided with occupation in distribution, cultural activities, and recreation.

Opportunity to work should be provided for every person dependent upon his own efforts. Obviously this opportunity cannot be supplied at the bottom of the scale of human endeavor, else over-production would result. But, there is always room at the top. The great need is for a stabilizer, in the form of activities disconnected from the production of material necessities, which will provide in every country a steady flow of money from hand to hand. This stabilizer is close at hand. It will not prevent, but it will mitigate recurrent business depressions.

The nation's spiritual and cultural advancement are of greater importance than provision for material well-being. Expenditures of public funds for such purposes comparable with those for the safeguarding of life and property, for the protection of health, and for facilitating the exchange of products would not be unreasonable, but there is fear of the tax burden. Under a well balanced program the nation should get vastly more scientific research, expansion of educational opportunity, and encouragement of art. Education and art advancement should be provided for in all centers of population, by the erection of monuments, the establishment of museums, art galleries, and conservatories of music, and by the maintenance of opera houses with opera companies. These expenditures would contribute to the spiritual uplift of the people and to the progress of civilization. Provision for outdoor recreation should be made throughout the land on a scale never yet approached. Lands should be reserved and acquired so that those who go into the open may find suitable places to picnic and to camp. During periods of declining prices there also should be a speeding up of public works, on a sane program. Recourse to pick and shovel, instead of modern appliances, is but a trifle above giving a dole with its encouragement of idleness and of return to primitive conditions.

The basis of such a program of course is a high rate of taxation, and any suggestion that the government spend more money, particularly in business depressions, is commonly frowned down. The fact is ignored that when capitalists close their purses, government must spend to avert disaster. Objection should not be to the magnitude of the sum to be raised, but to the prevailing unfair systems of apportioning the tax. If the burden were distributed commensurately with ability to pay, there would be less dissatisfaction and the public soon would learn that the greater the tax the less the slump in the aggregate volume of the country's business.

Tax money thus put into circulation would create a volume of business that readily could bear the tax from year to year. To make this clear, let it be supposed that times are hard, money scarce, and that Jones has run up a bill of $100 at the grocers. The grocer has gone into debt to a truck gardener in the same amount; the truck gardener owes the butcher $100; the butcher owes the baker; the baker owes the plumber; and so on 100 times creating a total indebtedness of $10,000 with 100 persons complaining of the difficulty of making collections. Jones finds employment and pays his grocery bill. The grocer pays the truck gardener with the $100 received from Jones and so on until a single $100 in a few days may have reduced outstanding indebtedness by $10,000. The dollar started keeps on going from person to person normally from 30 to 50 times in a year, until hoarded somewhere or until its speed is checked during some business depression. If money received from equitably levied taxation is spent economically at home it will, in passing from hand to hand, create business in the long run for each taxpayer in substantially the proportion in which he has contributed. Each dollar thus expended by the government should create from 30 to 50 dollars of business in a year with, of course, some annual shrinkage. There appears no reason, in theory, why taxes should not be welcomed.

Much unproductive property, such as furniture and works of art, is too heavily taxed. So also is real estate. Why tax the goods or the material which the merchant or manufacturer has in stock when his business is "in the red"? They should pay something for the privilege of doing business, based upon the volume of business, and they should contribute to the government a part of the net profits. The tax on real estate should be just enough to prevent the land from lying idle too long. The main guide in fixing the individual's tax should be ability to pay, that is to say, his net income. Taxes should be graded and there might well be a minimum below which there would be no taxes.

Indirect bonuses have increased the tax burden of those who do not get such bonuses. The veteran is granted tax exemption, amounting in some states to $1,000, an indirect bonus perhaps equivalent to $40 or $50 per year. Such exemption has almost universal approval. However, another veteran of necessity living in rented quarters with wife and children, and who therefore cannot benefit from the exemption, does not get the indirect bonus for which he probably is in much greater need. The exemption is unfair; every such bonus should be direct, not indirect.

Salaries of public employees and officials are tax free—equivalent to an addition to the individual's earnings—an indirect bonus automatically largest for those with largest incomes who best could afford to pay an income tax. Earned incomes are exempted from the federal base tax to an extent of 25 per cent. An indirect bonus equivalent to the tax on $1,250 thus is given to the man who has a salary of $5,000. His neighbor whose earned income is $30,000 obtains an indirect bonus *six times as great*, yet the latter is in better position to pay. Scientific, religious, and like institutions are exempted, equivalent to giving a bonus. To the extent of the aggregate indirect bonuses thus granted, the other tax payers carry a heavier burden.

Government, state, and municipal bonds are tax free, supposedly for advantage to the public on the basis that they thus become marketable at lower rates of interest—only a fancied advantage that may lead to injustice. All the bonds issued by one municipality may be held by residents of another. In the second city a corresponding amount of property is taken off the tax list, with the result that all other property is more heavily taxed. The increased burden thus results in advantage to the residents of another municipality. If all bonds issued by a municipality are owned by residents of that municipality, the tax rate on the remaining property must go up in an amount that will more than offset the advantage which results from the low interest rate at which the bonds were issued. If the holder of the bonds did not profit by the tax exemption, the low interest rate bonds would not be attractive—another indirect bonus.

When the Panama Canal was constructed bonds for nearly $400,000,000 were issued. These bonds went into the hands of bankers who deposited them in the United States Treasury for the privilege of issuing bank notes secured by these bonds. The bank notes, which may have approximated 90 per cent of the amount of outstanding bonds, went into circulation as currency, the banks thus being permitted to borrow from the public, at a small engraving cost and a moderate tax, hundreds of millions of dollars without paying interest—an indirect bonus.

Under the Reclamation Act of 1902, and its amendments, the settler is required to pay back to the government within 40 years the cost of the irrigation works, but without interest—an indirect bonus practically equivalent to the cost of the works. If constructed privately the works would have cost the settler twice as much.

Several cities in Kansas have no taxes, a situation welcomed by all. The cost of government has been shifted from the tax payer to the rate payer in water, light and power bills, and car-fares. The public utilities are owned by the municipalities and the profits are sufficient to meet the budget requirements. By this arrangement the *wealthy* have been *relieved of their just share* in the cost of government at the expense of those in moderate circumstances. Real estate owners and capitalists are presented with an indirect bonus.

Other illustrations could be given to indicate how general these indirect bonuses have become.

Equitable taxes and fair distribution of the cost of government is the first step to the expansion of activities for cultural progress and public welfare as a means of preventing extreme distress during business depressions.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

The Simplex Synchronous Motor

Salient-pole synchronous motors with phase-connected damper windings are capable of developing high starting and pull-in torques with low starting current, as revealed by information given here.

By
M. A. HYDE, JR.
Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

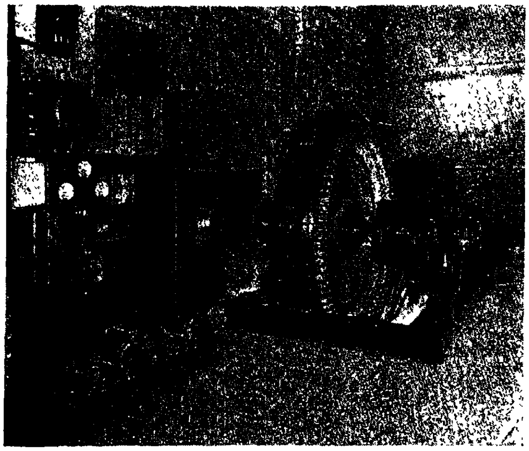


Fig. 1. A 300-hp. 164-r. p. m. synchronous motor of the phase-connected damper type and with associated control serving a cement plant

NOTEWORTHY PROGRESS has been made during recent years in the application of low-speed synchronous motors to industrial loads requiring both high starting and pull-in torques with moderate starting-current demand. The problems encountered are exemplified in the drive of grinding machinery in the cement and mining industries. There has been built for this type of service a form of salient-pole synchronous motor which develops these characteristics electrically without the use of any mechanical clutch or other loading device, and in a manner resembling the starting characteristic of the slip-ring induction motor.

Tests on machines of this type have shown starting torques in the order of 200 per cent of full-load torque, pull-in torques of 120 per cent and more, and starting-torque-per kva. ratios of from 0.6 to 0.7,

The construction is basically that of a two-bearing, coupled, salient-pole machine with certain deviations from the hitherto usual form. Instead of the ordinary cage form of damper winding this motor employs a damper winding consisting, as usual, of a single bar per slot in the pole face; but these bars are of low resistance copper and are connected to form a polyphase winding similar to the secondary winding of a slip-ring induction motor. This construction is shown in Fig. 2. The damper winding is connected through three slip-rings to an external grid-type starting resistor. In starting, this resistor is cut out in steps by the control as is done in starting a slip-ring induction motor and the damper winding circuit thus is given a succession of decreasing resistance values, providing advantageous speed-torque characteristics throughout the accelerating period.

It may be noticed in the rotor illustrated that the pole faces are comparatively broad, permitting the damper winding to occupy a large portion of the pole pitch and to be favorably distributed from the standpoint of phase balance. To avoid the high eddy currents normally present during starting in the usual solid rotor rim, the rim of this machine is laminated.

The motor is started with field open-circuited; this eliminates the low-power-factor current that ordinarily circulates in the field when closed on a resistor at start, as commonly is done. The disadvantage generally resulting from open-field starting is the high transformer voltage on the field winding at start, and to obviate this several motors of the type described have been constructed with field designed for low-voltage excitation. These proportions involve higher excitation and fewer field turns, the latter resulting in lower transformer voltage on the field winding. A 1,000-hp., 1,800-r. p. m. 100 per cent power-factor motor constructed for low-voltage excitation required 8 kw. at 45 volts direct current, and developed at standstill by transformer action 3,300 volts across the field terminals. This voltage diminishes to zero as the rotor accelerates to synchronism.

Since the transformer voltage on the field at start is proportional to the number of field turns in series, the practise of field sectionalizing may be used. After extensive shop and service tests some motors have been built in which a centrifugally-operated sectionalizing switch is employed to break up the field into sections at start and to connect the sections in series after acceleration to a predetermined speed, when the transformer voltage is correspondingly reduced. A 300-hp., 164-r. p. m., 100 per cent power-factor motor employing such a switch and with a field designed for 125-volt excitation developed about 3,000 volts per section. The switch is built as a unit enclosed in a tight housing

---

From "The Synchronous Motor with Phase-Connected Damper Winding for High-Torque Loads," (No. 31-43) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

and mounted within the rotor. Close scrutiny will discern one of these switches in the rotor of Fig. 2.

Control equipment employed with these motors is of magnetic definite-time-sequence type; its operation is explained by Fig. 3. In the control diagram the field is shown separated into three sections at standstill by the sectionalizing switch *F S*. In starting, the spring-closed auxiliary field switch *F*-1 is opened first; then the stator is connected to the a-c. supply with full starting resistance in the damper circuit. This resistance is shunted in steps by the closing of *S*-1, *S*-2, and *S*-3, and the motor accelerates along the corresponding speed-torque curves R_1, R_2, R_3, and R_0. Next the auxiliary-field switch *F*-1 is closed and the field, now connected to the field resistor, increases the induction-motor torque along curve R_{OF}. Finally d-c. excitation is applied by contactor *F*-2 and the motor synchronizes, operating thereafter as an ordinary salient-pole machine. In stopping, the centrifugal sectionalizing switch remains closed until a low speed is reached, permitting the field switch *F*-2 to be opened previously and a discharge circuit through the field resistor established. The control is arranged to prevent starting the motor with the field sectionalizing switch in the closed position. The auxiliary field switch is used to separate the field terminals from the control apparatus during starting, employing for this service a spring-closed contactor which ordinarily is mounted on a covered panel at the rear of the main panel.

The tabulation of starting performance given in Table I shows test results attained with several representative ratings during the development of this equipment. The starting-torque kva. ratios of 0.6 and 0.7 are about twice the values considered good for low-speed synchronous motors of ordinary construction when designed for similar torques.

It is interesting to compare this motor with the ordinary compressor motor. With a current inrush of 275 per cent the standard compressor motor torques are 50 per cent starting and 40 per cent pull-in, whereas the simplex motor delivers with this same starting current a starting torque of 150 per cent and a pull-in torque of 120 per cent. This high starting performance is obtained without sacrifice of efficiency, with excitation characteristics suited to commercial d-c. voltages, and with starting torque adjustable in value to suit the needs of the installation.

Table I—Simplex Motor Starting Performance

Hp. rating	1,000	300	300	350
Speed in r. p. m.	180	164	164	400
Power factor, per cent	100	100	100	80
Rotor rim construction	Solid	Solid	Laminated	Laminated
†Pull-in torque at 5 per cent slip	125	115	122	118
†Starting torque	210	210	230	190
†Starting kva., locked rotor	430	460	396	*268
Ratio of starting torque kva.	0.49	0.46	0.58	0.71

†Torque and kva. given in per cent of full-load value.
*Starting kva. based on 100 per cent power factor.

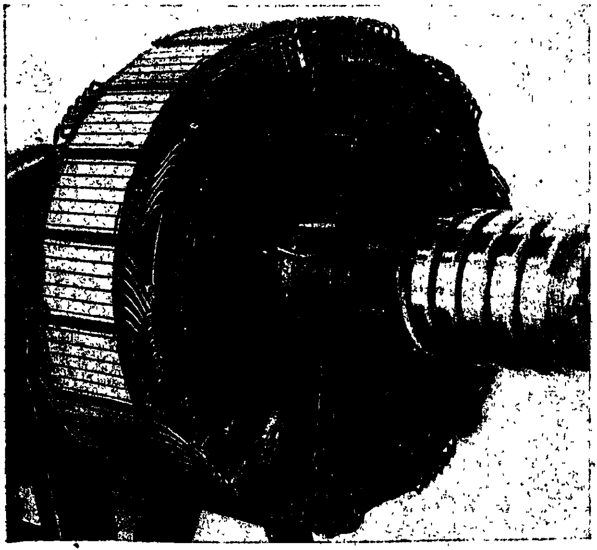


Fig. 2. Close-up of the rotor of a 225-hp. 360-r. p. m. motor with phase-connected damper windings

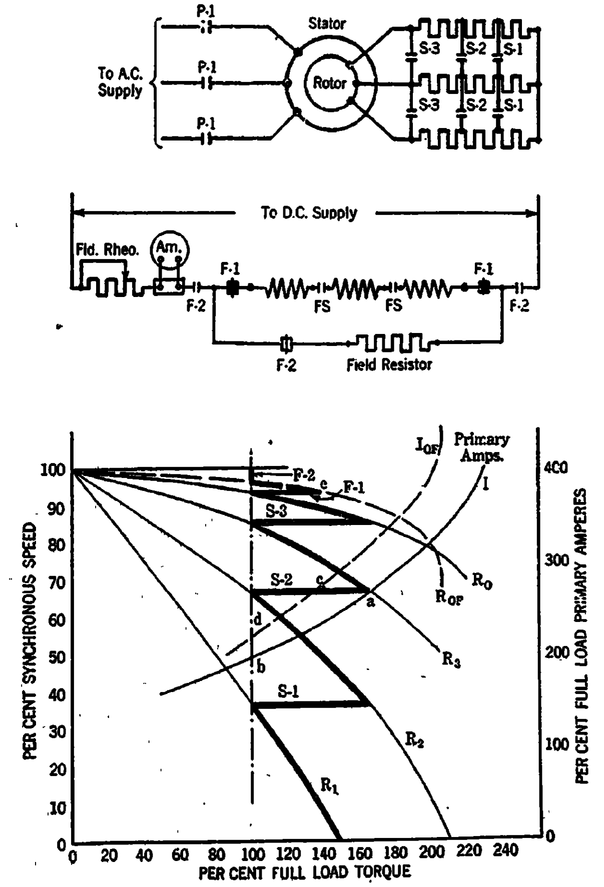


Fig. 3. Typical elementary control diagram (above) and associated speed-torque and current-torque curves (below)

Stabilization of Industry

Details are discussed of a plan which would provide for the regulation of industry through mutual trade associations under federal supervision. Production, consumption, and other factors would be coordinated to reduce cyclic variations; employees would participate jointly in providing unemployment insurance protection and other benefits which would accumulate for the employee regardless of legitimate changes in company or industry affiliations.

By
GERARD SWOPE
Fellow A. I. E. E.

President
General Electric Company

IN THE SITUATION that confronts us at the present, the most disturbing aspect is that men who are able to work, who are competent workers, who, above all things desire to work, cannot find work to do. That this condition ever has been present in such periods detracts nothing from its wrongness. That industry must evolve and make effective those measures which first will ameliorate, and ultimately eliminate it, must be the reaction of everyone who gives thought to what is taking place. I say that industry must do this thing, because surely it will be done.

Benefits earned by a worker in one employment are wholly or in large measure lost by forced changes; or the right of choice of employment, which should be inalienable, is hampered. From the operation of individual life insurance and pension systems, however well conceived, has arisen the complaint of the "forty-year dead line," which it is claimed has seriously affected the ability of men exceeding that age to find new employment. Wide application is essential if benefits gained in one location are to follow the worker as necessity may indicate change of location, and this is a vital factor of any plan which will meet the need. If there were provided in the United States a system of benefits accruing through the life of the worker and following him wherever he might go, from shop to shop within a particular industry, or from branch to branch within industry as a whole, such provision would enlist, not merely interest on the part of the worker, but enthusiastic support.

PRODUCTION AND CONSUMPTION MUST BE COÖRDINATED

Industry exists basically for serving the needs of the people, and therefore production and consumption must be coordinated. Consumption is by the mass of the population, not the few, and the great mass of the population is made up of wage earners and their dependents. That they may be able to buy and satisfy their needs, they must have not only adequate incomes but must be sufficiently assured of the future to feel that they are safe in spending their money. The psychology of fear must be removed; and this cannot be done unless they have reasonable expectation of protection for their families in case of the breadwinner's death, protection for their old age, and protection against unemployment. By "protection" I do not mean a protection that is given to them, but I mean protection that they themselves help to provide.

Shall we wait for society to act through its legislatures, or shall industry recognize its obligation to its employees and to the public and undertake the task? Coordination of production is impossible under our present laws, and it is vain to think of their amendment or repeal unless the public is assured of the constructive nature of the steps industry will take, and that the interests of the public will be adequately safeguarded.

UNDERLYING PRINCIPLES

The general principles underlying what I am going to say are as follows:

1. Every effort should be made to stabilize industry and thereby stabilize employment to give to the worker regularity and continuity of employment; and when this is impracticable, unemployment insurance should be provided.

2. Organized industry should take the lead, recognizing its responsibility to its employees, to the public, and to its stockholders—rather than that democratic society should act through its government. If the various states act, industry will be confronted with different solutions, lacking uniformity and imposing varying burdens, making competition on a national scale difficult. If either the individual states or the federal government act, the power of taxation has no economic restraints.

3. There should be standardized forms of reports so that stockholders may be properly informed. As a result of the steady increase in number and size of corporations and number of shareholders, there has been much discussion of the uniformity, frequency, and regularity of reports of corporate activities, and considerable criticism of the form of these reports. Some are too conservative, some not sufficiently complete, while others are considered to be fair and complete. There is a lack of uniformity among the different companies.

4. Production and consumption should be coordinated on a broader and more intelligent basis thus tending to regularize employment and thereby removing fear from the minds of the workers as to continuity of employment, as to their surviving dependents in case of death, and as to old age. This should be done preferably by the joint participation and joint administra-

---

An address delivered before the National Electrical Manufacturers Association at the Hotel Commodore, New York, N. Y., Sept. 16, 1931.

tion of management and employees. These things cannot be done by an individual unit—organized industry must do them.

5. If organized industry is to undertake this work, every effort should be made to preserve the benefits of individual originality, initiative, and enterprise, and to see that the public is assured that its interests will be protected. This can be done most effectively by working through the agency of the federal government.

There is nothing new or original in what I am proposing. I am merely bringing together well-considered propositions that have found support, including some that have been put into actual practise.

The following plan is offered as a means to correlate into a comprehensive whole the present undirected efforts of forward-looking business enterprises toward stabilization (1) for the further development of industry and commerce, (2) for the protection of employees and stockholders, (3) for the best service to the public, and (4) in general for the best interests of society. Legislation will be required to make such a plan possible, including the probable modification of some existing laws.

Trade Associations the Answer

An outline of the more important features of a possible "industrial constitution" is given in the following paragraphs:

1. All industrial and commercial companies (including subsidiaries) with 50 or more employees, and doing an interstate business, may form a trade association which shall be under the supervision of a federal body referred to later.

2. These trade associations may outline trade practises, business ethics, methods of standard accounting and cost practise, standard forms of balance sheet and earnings statement, etc., and may collect and distribute information on volume of business transacted, inventories of merchandise on hand, simplification and standardization of products, stabilization of prices, and all matters which may arise from time to time relating to the growth and development of industry and commerce in order to promote stabilization of employment and give the best service to the public. Much of this sort of exchange of information and data already is being carried on by trade associatons now in existence. A great deal more valuable work of this character is possible.

3. The public interest shall be protected by the supervision of companies and trade associations by the Federal Trade Commission or by a bureau of the Department of Commerce or by some federal supervisory body specially constituted.

4. All companies within the scope of this plan shall be required to adopt standard accounting and cost systems and standardized forms of balance sheet and earnings statement. These systems and forms may differ for the different industries, but will follow a uniform plan for each industry as adopted by the trade association and approved by the federal supervisory body.

5. All companies with participants or stockholders numbering 25 or more, and living in more than one state, shall send to its participants or stockholders and to the supervisory body at least once each quarter and in the prescribed form a statement of their business and earnings. At least once each year they shall send to the participants or stockholders and to the supervisory body a complete balance sheet and earnings statement in the prescribed form. In this way the owners will be kept informed of the conditions of the business in such detail that there may be no criticism of irregularity or infrequency of statements or methods of presentation.

6. The federal supervisory body shall cooperate with the Bureau of Internal Revenue and the trade associations in developing for each industry standardized forms of balance sheet and income statement, depending upon the character of the business, for the purpose of reconciling methods of reporting assets and income with the basis of values and income calculated for federal tax purposes.

7. All of the companies of the character described herein may immediately adopt the provisions of this plan but shall be required to do so within three years unless the time is extended by the federal supervisory body. Similar companies formed after the plan becomes effective may come in at once, but shall be required to come in before the expiration of three years from the date of their organization unless the time is extended by the federal supervisory body.

Protection for Employees

8. For the protection of employees, the following plans shall be adopted by all of these companies:

8A. *A Workmen's Compensation Act*, which is part of the legislation necessary under this plan, after careful study, shall be modeled after the best features of the laws which have been enacted by the several states.

8B. *Life and Disability Insurance.* All employees of companies included in this plan may, after two years of service with such companies, and shall, before the expiration of five years of service, be covered by life and disability insurance.

I. The form of policy shall be determined by the association of which the company is a member and approved by the federal supervisory body. The policy will belong to the employee and may be retained by him and kept in full force when he changes his employment or otherwise discontinues particular service as outlined later.

II. The face value of a policy shall be for an amount approximately equal to one year's pay, but not more than $5,000, with the exception that the employee may, if he desires, increase at his own cost the amount of insurance carried, subject to the approval of the board of administrators, later defined.

III. The cost of this life and disability insurance shall be paid one-half by the employee and one-half by the company for which he works, with the following exception: The company's cost shall be determined on the basis of premiums at actual age of employees less than 35 years old and on the basis of 35 years of age for all employees 35 or over and shall be a face value of approximately one-half a year's pay but limited to a maximum premium for $2,500 of insurance. An employee taking out insurance at age 35 or over will pay the excess premium over the amount based upon age 35. This will remove the necessity for restriction against engaging employees or transferring them from one company to another because of advanced age, as it will place no undue burden of high premiums upon the company.

IV. The life and disability insurance may be carried by a life insurance company selected by the trade association and approved by the federal supervisory body, or may be carried by a company organized by the trade association and approved by the federal supervisory body, or a single company may be formed to serve all associations.

V. The administration of the insurance plan for each company shall be under the direction of a board of administrators consisting of representatives, one-half appointed by the management and one-half elected by the employee members. The powers and duties of the board for each company will be to formulate general rules relating to eligibility of employees, etc., but such rules shall be in consonance with the general plan laid down by the general board of administration of the trade association of which the company is a member, and approved by the federal supervisory body.

VI. Provision for the continuation of a policy after an employee leaves one company and goes to another in the same association or goes to a company in another trade association, continuance of the policy after retirement on pension, provisions with regard to beneficiaries, total or partial disability, method of payment of premiums by payroll deductions or otherwise, weekly, monthly or annually, shall be embodied in the plan formulated by the trade association, with the approval of the federal supervisory body.

VII. If an employee leaves a company to go with one which is not a member of the trade association, if he engages in business for himself, or if he withdraws from industrial or commercial occupation, he may elect to retain the portion of the policy for which he has paid in whole or in part, by the continued payment of the proportional full premium costs; or he may receive a paid up policy, or be paid the cash surrender value for the part for which he has been paying premiums. The cash surrender value of that portion of the policy paid for by the company will be paid to the company which paid the premiums.

8C. *Pensions.* All employees of companies included in this plan shall be covered by old age pension plans which will be adopted by the trade associations and approved by the federal supervisory body. The principal provisions will be as follows:

I. All employees may, after two years of service with a company coming within the scope of this plan, and shall, before the expiration of five years of service, be covered by the old age pension plan.

II. All employees after two years' service may, and after five years' service shall be required to, put aside a minimum of 1 per cent of earnings, but not more than $50 per year, for the pension fund. The employee may if he desires put aside a larger amount subject to the approval of the board of administrators.

III. The company shall be required to put aside an amount equal to the minimum stated above; namely 1 per cent of earnings of employees but not more than $50 per year per employee.

IV. The above minimum percentage shall be the same for all employees who are less than 35 years of age when payments begin and the minimum percentage for these employees shall remain the same thereafter. The percentage to be set aside by employees coming into the pension plan at 35 years of age or over shall be so determined that it will provide a retiring allowance at age 70 the same as though they had begun 1 per cent payments at age 35. These provisions enable employees to go from one company to another in the same association or to different associations at any age, with provision for retiring allowance which will be not less than the minimum rate of an employee who entered the pension plan at age 35.

V. The amounts set aside by the employee and the company with interest compounded semiannually at five per cent until retirement at age 70, for a typical average employee, would provide an annuity of approximately one-half pay.

VI. The administration of the pension plan for each company shall be under the direction of a board of administrators, consisting of representatives, one-half appointed by the management and one-half elected by the employee members. The powers and duties of the board for each company will be to formulate general rules relating to eligibility of employees, conditions of retirement, etc., but such rules shall be in consonance with the general plan laid down by the general board of administration of the trade association of which the company is a member, and approved by the federal supervisory body.

VII. The amounts collected from the employees and the companies shall be placed with a pension trust organized by the association, the management of which shall be under the direction of the general board of administration referred to hereafter. In no case shall such funds be left under the control of an individual company.

VIII. The pension trust shall invest all funds and place them to the credit of the individual employees, including the income earned by the trust. If an employee goes from one company to another in the same association, the funds accumulated to his credit shall be continued to his credit with proper record of transfer. If an employee goes to a company in another association, the funds accumulated to his credit shall be transferred to his credit in the pension trust of the associaton to which he goes. If an employee goes to a company which does not come under these provisions or which is not a member of a trade association, goes into business for himself, or withdraws from an industrial or commercial occupation, the amount of his payments plus the interest at the average rate earned by the funds shall be given to him. If an employee dies before reaching retirement age, his beneficiary will receive the amount of his payments plus interest at the average rate earned by the funds. When an employee reaches retirement age the entire amount accumulated to his credit, including his own payments and those of the company plus accumulated interest will be given to him in the form of an annuity.

If an employee goes to a company which does not come under these provisions or which is not a member of a trade association, goes into business for himself, or withdraws from industrial or commercial occupation, he may elect to let the amount to his credit (namely, his own payments plus those of the company and the accumulated interest) remain with the pension trust for transfer, if he should return to the employ of any company coming within the provisions of this plan. If he does not return to the employ of a company coming under these provisions he may at any time thereafter withdraw the amount of his own payments plus interest at the average rate earned by the funds up to that time. Company contributions and accumulated interest, credited to employees who die or for reasons indicated above receive or withdraw their own contributions and interest, shall be returned to the employer or employers who made the contributions.

IX. The rules governing the payments of pensions on retirement and all other rules governing its continuance shall be made by the trade association, approved by the federal supervisory body, and observed by the general board of administration and the boards of administration of the member companies.

8D. *Unemployment Insurance.* All employees on piece work, hourly work, daily, weekly, or monthly work, with normal pay of $5,000 per year or less (approximately $96.15 per week) shall be covered by unemployment insurance.

I. All such employees may, after two years of service with a company coming within the provisions of this plan, and shall, after five years of service, be each required to put aside a minimum of one per cent of earnings, but not more than $50 per year for an unemployment insurance fund.

II. The company shall be required to put aside an amount equal to that put aside by the employees, as set forth above; namely 1 per cent of the earnings of each employee but not more than $50 per year for each such employee.

III. If a company regularizes and guarantees employment for at least 50 per cent of the normal wage paid each year to such employees, the company assessment for employees covered by such guarantee need not be made, but the employees will pay a minimum of 1 per cent of earnings, but not more than $50 per year, into a special fund for their own benefit.

If such an employee leaves the company, dies, or retires on pension, the amount to his credit in the special fund plus interest at the average rate earned by the special fund, shall be given to him or to his beneficiaries or added to his pension.

IV. If a company so plans its work that it is able to reduce unemployment, when the amount of such company's credit in the normal unemployment fund is equal to, but not less than, 5 per cent of the normal annual earnings of the employees covered, the company may cease making payment to the fund. Employees' payments will continue. The company will resume payments when its credit in the normal unemployment fund falls below 5 per cent of normal annual earnings of the employees covered.

V. When the weekly payments made from the fund for unemployment benefits amount to 2 per cent or more of the average weekly earnings of participating employees, the company shall retire an unemployment emergency, and normal payments by the employees and the company shall cease. Thereafter *all* employees of the company (including the highest officers) receiving 50 per cent or more of their average full-time earnings shall pay 1 per cent of their current earnings to the unemployment fund. A similar amount shall be paid into the fund by the company. The unemployment emergency shall continue until normal conditions are restored, which shall be determined by the board of administrators of each company. Thereupon normal payments will be resumed.

VI. The main provisions for the distribution of the funds shall follow along these lines unless modified by the board of administrators as set forth in section D paragraph VII hereof. A certain small percentage of the normal payments of the employees and the company may be considered as available for helping participating employees in need. A larger percentage of such normal payments may be considered as available for loans to participating employees in amounts not exceeding $200 each, with or without interest, as may be determined by the board. The balance of the funds shall be available for unemployment payments.

Unemployment payments shall begin after the first two weeks of unemployment and shall amount to approximately 50 per cent of the participating employee's average weekly or monthly earnings for full time, but in no case more than $20 per week. Such payments to individual employees shall continue for no longer than ten weeks in any twelve consecutive months unless extended by the board. When a participating employee is working part time because of lack of work and receiving less than 50 per cent of his average weekly or monthly earnings for full time, he shall be eligible for payments to be made from the fund, amounting to the difference between the amount he is receiving as wages from the company and the maximum to which he may be entitled as outlined above.

VII. The custody and investment of funds and administration of the unemployment insurance plan for each company shall be under the direction of a board of administrators, consisting of representatives, one-half appointed by the management and one-half elected by the employee members. The powers and duties of the board shall be to formulate general rules relating to eligibility of employees, the waiting period before benefits are paid, amounts of benefits and how long they shall continue in any year, whether loans shall be made in time of unemployment or need, whether a portion of the funds shall be placed at the disposal of the board for relief from need arising from causes other than unemployment, tc.; but such rules shall be in consonance with the general plan laid down by the general board of administration of the trade association of which the company is a member, and approved by the federal supervisory body.

VIII. If an employee leaves the company and goes to work for another company coming within the provisions of this plan, the proportionate amount remaining of his normal contributions plus interest at the average rate earned by the funds shall be transferred to such company and to his credit. If he leaves for other reasons, dies, or retires on pension, the proportionate amount remaining of his normal payment plus interest at the average rate earned by the funds shall be given to him or to his beneficiary, or added to his pension. When such employee's credit is transferred to another company or paid to the employee or to his beneficiary under this provision, an equal amount shall be paid to the cooperating company.

9. *General Administration.* Each trade association will form a general board of administration which shall consist of nine members, three to be elected or appointed by the association, three to be elected by the employees of the member companies, and three representing the public to be appointed by the federal supervisory body. The members of the general board, except employee representatives, shall serve without compensation. The employee representatives shall be paid their regular rates of pay for time devoted to board work, and all members shall be paid traveling expenses, all of which shall be borne by the trade association. The powers and duties of this general board shall be to interpret the life and disability insurance, pension, and unemployment insurance plans, adopted by the trade association and approved by the federal supervisory body, supervise the individual company boards of administration, form and direct a pension trust for the custody, investment, and disbursements of the pension funds, and in general supervise and direct all activities connected with life and disability insurance, pension, and unemployment insurance plans.

CONCLUSIONS

The foregoing plan tends to put all domestic corporations of the class described on a parity for domestic business, thereby removing the inequalities of the different laws in the several states, provides for standard forms of financial reports and their periodical issuance for the information of stockholders, places on organized industry the obligation of coordinating production and consumption, and of a higher degree of stabilization. This will tend to assure more uniform and continuous employment for the worker and to remove fear from his mind, allowing him to devote himself whole-heartedly to his task. Cost of the product will include these items and will therefore be paid for by the users of the article or service and not in general by members of the community reached by the vicarious method of the imposition of a tax. Then organized industry will be in the position that it should rightly assume of serving the public, with public confidence and with the joint participation of workmen and management in the solution of these vital and far-reaching problems.

The following provision is suggested to place domestic corporations of the sort described on a parity with foreign competition: Any company engaged in export business may, upon application to, and approval by, the federal supervisory body, deduct from its federal income tax the equivalent of X per cent of its export sales, this X per cent deemed to be the equivalent in selling price of the various provisions for the benefit of employees which the company must make under this plan, and from which some foreign companies which the domestic companies have to meet in competition are free.

By this method American industry can discharge its obligation to its employees and by holding its position in world markets, bring additional work to America.

Synchronous Motors for Special Loads

The field of the synchronous motor can be considerably widened by variations in the design of normal motors of this type. Special requirements in starting current and in starting, pull-in, and pull-out torque can be met without resorting to unusual forms of motor design.

By
D. W. McLENEGAN
Associate A. I. E. E.

A. G. FERRISS
Non-member

Both of the
General Electric Co.,
Schenectady, New York

SYNCHRONOUS motors have been applied in recent years to drives for which only the induction motor was formerly considered suitable. This practise has resulted from the need for motors operating at unity or leading power factor and for motors having high efficiency at low speeds. The use of synchronous motors for these applications has been made possible by great improvements in starting characteristics and mechanical design as well as new methods of control.

The conventional type of synchronous motor is of course the salient-pole machine, as it permits that the field-copper space be a maximum, thus taking full advantage of separate excitation with the large number of field ampere-turns required. Due to its greater excitation capacity, the salient-pole synchronous motor may employ a relatively large air-gap, which is mechanically desirable, without impairment of electrical characteristics. Small air-gaps on the order of 0.25 per cent of the pole pitch must be used on induction motors to reduce the magnetizing kva. Mechanical limitations prevent the use of air-gaps smaller than about 0.1 per cent of the diameter, so that induction motors with more than eight poles are definitely handicapped. The normal design of the salient-pole synchronous motor permits a natural air-gap of the order of 1½ to 2 per cent of the pole pitch and mechanical limitations are not reached until the motor has 60 poles or more. For this reason, the lower the speed the more favorable are the synchronous motor char-

---

From "Synchronous Motors—Design and Application to Meet Special Requirements," (No. 31-52) presented at the winter convention of the A. I. E. E., New York, January 26-30, 1931.

acteristics in comparison with those of the induction motor.

The large air-gap also makes possible the use of larger stator slots with consequent improvement of space factor and efficiency. As high-frequency flux pulsations cannot cross a large air-gap, thicker laminations may be used in the pole pieces. Space is provided in the normal design of the pole face for an amortisseur winding with ample heat capacity to enable the motor to start most industrial loads.

The normal type of synchronous motor which is best suited for steady-load operation has the above design characteristics. However, starting and accelerating characteristics vary with speed and horsepower, and the type of load may require motor characteristics different from those given by normal design. Without abandoning the basic form of synchronous motor outlined above, the electrical design may be proportioned to attain the characteristics required for many exacting operations.

A 100-hp. 60-pole motor will have high reactance, and consequently low starting and pull-in torque, while the 1,000-hp. 20-pole motor will have low reactance and high starting and pull-in torque. The empirical curves of Fig. 1 approximate the relationship between torques at synchronous and subsynchronous speeds for 60 cycles, 450 r. p. m., and lower. It is evident that for many applications involving low-speed motors it is necessary to find means of increasing the starting and accelerating torque; while for high-speed motors it is frequently desirable to reduce both the torque and the starting inrush. For the normal low-speed machine the starting inrush is 250 to 350 per cent of the kva. rating at approximately 30 per cent power-factor lagging; while for high-speed machines the inrush varies from 500 to 800 per cent of normal rating at 30 to 50 per cent power factor.

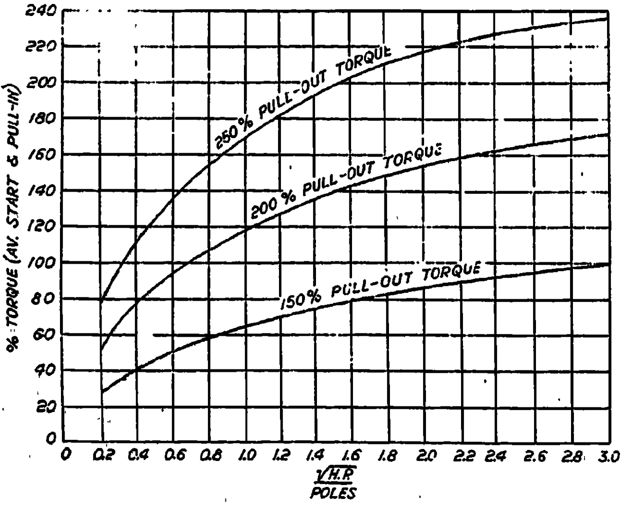


Fig. 1. Relation of starting torque to pull-out torque for various sizes and speeds of 60-cycle, unity-power-factor synchronous motors below 450 r. p. m.

REDUCTION OF STARTING CURRENT AND TORQUE

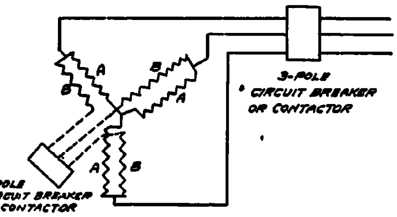
Heretofore where reduction of starting current or torque has been required, auto-transformers have been most widely used, while series reactors and resistors are sometimes used because of simplicity.

Increasing the reactance in the primary windings of the motor at starting reduces the inrush and torque without modifying the synchronous characteristics and without an external voltage-reducing device. This may be secured by the use of a double-circuit stator winding, the external connections being shown in Fig. 2. One branch of each phase is energized at start, the other branch being connected in parallel as substantially full speed is attained.

The reactance of the motor at start with only half the coils energized is much greater than with all the coils energized. The reduced current input creates less flux to act on the rotor and consequently less torque is developed, as shown in Fig. 3. As with reactor starting, the torque characteristics approach normal during acceleration. This is particularly desirable for blower and centrifugal-pump drives.

A somewhat different application of the double-winding motor is to start without shock high-torque loads such as ball mills, tube mills, and pulverizers. When the first circuit is energized, the motor develops sufficient torque to take up all gear and coupling slack. Energizing the second circuit starts and accelerates the load without shock to the mechanical parts, and voltage disturbances on the line are minimized.

Fig. 2. External connections for starting with double-circuit stator winding


A
B
B
A
A
B
3-POLE CIRCUIT BREAKER OR CONTACTOR
2-POLE CIRCUIT BREAKER OR CONTACTOR

INCREASE OF STARTING TORQUES

The need for starting and pull-in torques greater than those of a normal motor occurs most frequently with low-speed motors. Considering this group, the following methods are available for increasing the subsynchronous torques.

Oversize Motors. Increased torque in starting may be secured by an oversize motor, similar to the normal motor but built to larger dimensions for a given rating to make room for a greater total magnetic flux. Without restricting the magnetic section, the wide pole pieces accommodate more bars. These may be arranged on a double squirrel-cage, using high- and low-reactance elements to improve the torque per ampere and to fit the speed-torque characteristics to the load requirement. The speed-torque curves in Fig. 4 indicate the uniform torque obtainable from start to synchronism.

This type of motor is widely used on rubber mills, ball and tube mills, crushers, and on certain types of compressors. High efficiency, ample thermal capacity in the amortisseur winding, and simplicity in design, construction and control are the factors favoring this type of motor. Double-winding increment starting is available to meet objections to the sudden applications of high torque and to excessive voltage dips.

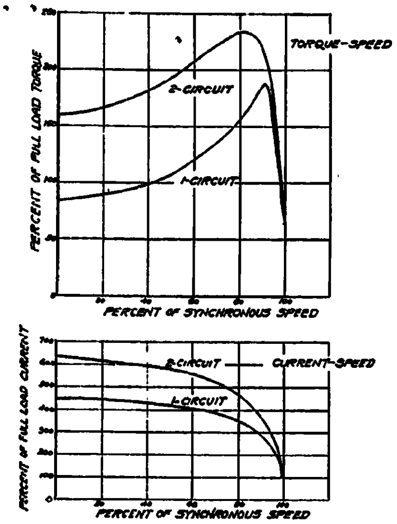


Fig. 3. Starting characteristics of an 800-hp., unity-power-factor, 1,200-r. p. m. synchronous motor with double-circuit stator winding

The use of the high-torque motor is extended by installing reliable intermittent rated capacitors for supplying part of the magnetizing current during starting. Frequently, one capacitor can be used for starting several motors, and by cutting out the capacitor in steps as the motor accelerates, the kva. demand may be regulated so as to prevent objectionable voltage variations.

Overvoltage Starting. Where high-torque design is at a disadvantage in very slow-speed rating because of excessive size, weight, or torque, a normal motor with overvoltage starting may well be applied. Overvoltage starting of normal low-speed motors does not present any difficulties to the manufacturer. With 150 to 175 per cent starting voltage, a low-speed, low-torque motor is not subjected to any higher percentage of current or torque than is a high-speed motor started on full voltage. The short, stiff end turns of the stator coils in a low-speed motor require little or no bracing to withstand starting stresses.

Overvoltage starting may be accomplished by stepping up the line voltage through an auto-transformer or by applying line voltage to only a part of a transformer primary winding. Starting torque varies as the square of the applied voltage plus a slight increase which comes from the fact that saturation decreases the starting reactance. If high pull-in torque is also required, as for starting a pulverizer with full charge, the motor can be synchronized before the voltage is reduced to normal. This is best done without interrupting power so as not to let the motor drop out of step.

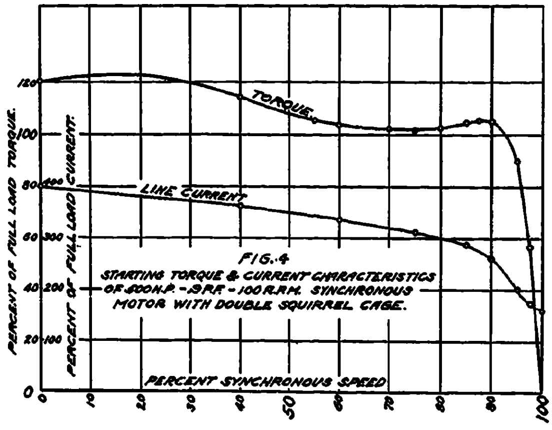


Fig. 4. Starting characteristics of a large low-speed rubber mill motor

Delta-Star Starting. Delta-star starting has been successfully used on motors required to start a heavy load with moderate inertia characteristic, but since the circuit must be interrupted in changing to normal connections after synchronizing, it is doubtful if large high-voltage circuit breakers are sufficiently fast to keep the motor in step. Moreover, no adjustment of starting characteristics is possible except in the motor design.

Tapped-Winding Starting. Where it is found that a relatively small increase in starting or pull-in torque is required, a few coils of each phase may be cut out to decrease reactance and increase input. This procedure lowers synchronous reactance, raises densities and core loss, and calls for more excitation.

In a deliberate design it is possible to arrange the end connections so that a number of coils in each phase are cut out while starting on full voltage and picked up again after acceleration, so that full synchronous reactance is restored. Tests indicate an effect similar to, but weaker than, overvoltage starting.

Phase-Wound Starting Windings. As the wound-rotor induction motor with external rheostats in the secondary circuit has excellent starting torque and current characteristics, many attempts have been made to combine these with the advantages of synchronous operation. By using such a motor with slightly larger air-gaps and fewer and larger rotor slots than normal for an induction machine, the synchronous induction motor, widely used abroad, is obtained. The slip-rings are connected to rheostats in starting, and to a d-c. source at speed. This permits a much higher ratio of starting torque to starting inrush than is obtainable in the normal motor.

The three fundamental difficulties with this type of motor are high cost, low efficiency, and high ratio of starting to rotor excitation voltage. The rotor starting voltage at full-load torque may be some fifty times the excitation voltage unless changes in connections are made. These difficulties tend to limit the application of the synchronous induction motor to a few cases of high-speed motors, where the disadvantage of increased excitation loss is minimized.

Another scheme that presents interesting possibilities is the use of a normal salient-pole synchronous motor with a phase winding in the pole phases. This scheme has the distinct advantage of permitting normal efficiency to be attained, but it introduces a more complicated mechanical construction, and does not permit as great a torque efficiency as the normal wound-rotor induction-motor construction. The phase winding must be carefully insulated and mechanically braced for high-speed motors, and this hampers accessibility of the field windings. To secure good starting characteristics and adequate heat capacity in the phase winding, it is desirable to use special pole construction at added expense. To permit full flux and torque to exist at starting, the field winding must be open-circuited, with resulting very high induced voltage unless special low-voltage excitation is used. To avoid the latter, it is customary to sectionalize the field winding while starting.

Supersynchronous Motors. The supersynchronous motor differs from the normal machine in that the external primary element is supported by bearings and is surrounded by a brake band. In starting, the primary is brought up to speed in the reverse direction and synchronized while the rotor with its connected load stands still. Gradual application of the brake slows down the primary, and starts and accelerates the rotor and load. Thus the pull-out torque of the motor is available during starting and accelerating, and rated power factor prevails. The advantages of smooth control of acceleration and controllable low starting current combined with high torque make this motor widely used in cement mills, on line shafts, mine fans, and similar applications. The design is not applicable to high-speed motors, and unless its unique characteristics are important for a specific application, it is generally preferable to use a normal-type motor with the proper control features.

One factor that should not be lost sight of is that in any group of commercial designs in standard frames, some ratings will have more favorable starting-torque characteristics than others; and in specific cases it is often possible to enlarge the amortisseur bars and increase the accelerating capacity well beyond the usual value. By this means normal-type motors may be built with an amortisseur winding to accelerate heavy loads, and much of the heat generated in the bars during a gradual acceleration passes directly into the pole pieces. The permissible temperature of the bars is not limited by contact with any insulating material. In low-speed motors the thermal capacity of the amortisseur seldom requires any modification of the normal design, because of the relatively large diameter required for a low-speed motor.

At the other extreme, two-pole synchronous motors are found to have excellent accelerating capacity in spite of the small motor diameter. By making the amortisseur in the form of very deep bars placed at the sides of rotor slots, a larger surface is provided for transferring heat to the rotor iron.

In general, for synchronizing with a large inertia, a normal motor with either a phase winding or a squirrel-cage can be designed with very low resistance to develop high torque at very low slip. It seems to be characteristic of most flywheel loads that the load at starting is not high; hence the moderate starting torque obtained with a low-resistance squirrel cage of normal reactance is usually adequate for starting loads of this type.

SYNCHRONOUS CHARACTERISTICS

The use of synchronous motors on steady loads does not present any unusual problems involving the synchronous characteristics. But where irregular loads and high momentary peaks occur, it is necessary to modify the normal design to insure successful operation.

In any application which involves wide swings of load, the first question in selecting a motor is the power supply. If the capacity is relatively large, and power swings corresponding in magnitude to the load swings are not objectionable, the first point is established in favor of the synchronous motor. If the supply is limited, and the load swings occur at very short intervals, the wound-rotor induction motor with a flywheel and a slip regulator is still in demand.

If it is found that the load swings can be assimilated by the power system, the characteristics of the synchronous motor itself must be considered. For any practical case involving peak loads of the order of one-half second duration or more, three alternatives are possible in applying a synchronous motor:

1. Provide a motor with sufficiently high sustained pull-out torque to carry the load without losing synchronism.
2. Remove excitation and allow the motor to run on the amortisseur winding, resynchronizing after load has been reduced.
3. Automatically apply excess excitation to motor field during heavy overloads.

The first method, which amounts to building an oversize motor, is particularly applicable where the load swings occur frequently. Although unity power-factor motors can be designed to develop 300 per cent pull-out torque or more by resorting to a very large air-gap and low-armature reaction, such motors in general will be larger than leading power-factor motors which develop the same pull-out torque. Since the synchronous motor is often chosen primarily for power-factor improvement, motors of 80 per cent or even 70 per cent leading power factor are commonly selected.

Even with this torque available, motors are occasionally thrown out of step by extreme overloads, and a study must frequently be made of the flywheel effect of the machine, together with the sustaining torque of the amortisseur winding, to determine whether the motor can carry through the peak load without too great a reduction in speed. With adequate data the speed reduction can be estimated closely; and if this is not too large, the duty of accelerating back to synchronous speed will not endanger the amortisseur winding, since the heating of this element for a given output, varies with the slip.

After a motor has been forced out of synchronism, the d-c. excitation must be removed temporarily since otherwise the motor would generate a braking torque in opposition to the accelerating torque of the amortisseur winding. Then the load must be limited also to a value which will enable the motor to resynchronize, the means of limiting this load depending upon the type of load.

For meeting such conditions where the motor may be pulled out of step frequently, the synchronous induction motor would be well suited except for the inherently low pull-out torque of this type. If designed for good starting characteristics, unity-power-factor designs will have only 120 to 140 per cent pull-out torque. By designing for 0.8 leading power factor, 175 to 200 per cent pull-out torque can be obtained. If the overexcitation is further increased to obtain still higher synchronous torque, the loss in efficiency may be serious. Obviously, the wound-rotor machine can be justified only by very severe accelerating duty or starting current requirements.

Many possibilities for increasing pull-out torque are presented by quick-response excitation. If a synchronous motor is subjected to occasional peak loads much greater than the average load, and the field excitation can be quickly increased to meet these overloads, a material reduction in the size and cost of the motor is sometimes possible. In addition, the motor may be designed for best efficiency at the average load condition, and the motor power factor will be held more nearly constant during the load changes. The problem is the same as that involved in overexcitation of generators to maintain synchronism during short circuits, except that most industrial motor installations cannot justify the refinement and expense of the equipment used with large generators.

When a heavy load is suddenly applied, a synchronous motor can momentarily exert a torque far greater than its sustained maximum torque. This usually gives sufficient current for changes in excitation to be made, provided the excitation system is sufficiently fast. In the larger motor sizes, modification of the exciter may be necessary to increase its rate of voltage rise. For small motors, such as 100-hp., usually it will be more economical to build a motor having this higher torque inherently, than to resort to overexcitation with a larger exciter and additional control.

Another method of overexcitation which is sometimes used is to operate a 125-volt exciter at 175 or 200 volts for example, and dissipate the difference between this value and 125 volts in a fixed resistor in series with the motor field. A contactor is then used to short-circuit the resistor when the motor load exceeds a predetermined value.

Interesting possibilities are found in the use of electron tubes for overexciting a synchronous motor, although this has not yet been applied commercially. In applying any field-forcing scheme, the motor field must be of liberal design so that the intermittent high excitation will not overheat the field coils. With adequate margin provided, however, the field winding can still be considerably smaller than that of an equivalent high-torque motor which carries high excitation current continuously.

Severe Lightning Tests Made on "Surge-Proof" Transformers

AN INTERESTING SERIES of lightning tests was made on Sunday, August 23, by the Westinghouse Electric and Manufacturing Company on each of four 42,000-kva., 220-kv. single-phase transformers. These units are of the new non-oscillating surge-proof type of construction recently developed by this company, which states that the transformers embody features of insulation design effecting greatly improved impulse strength.

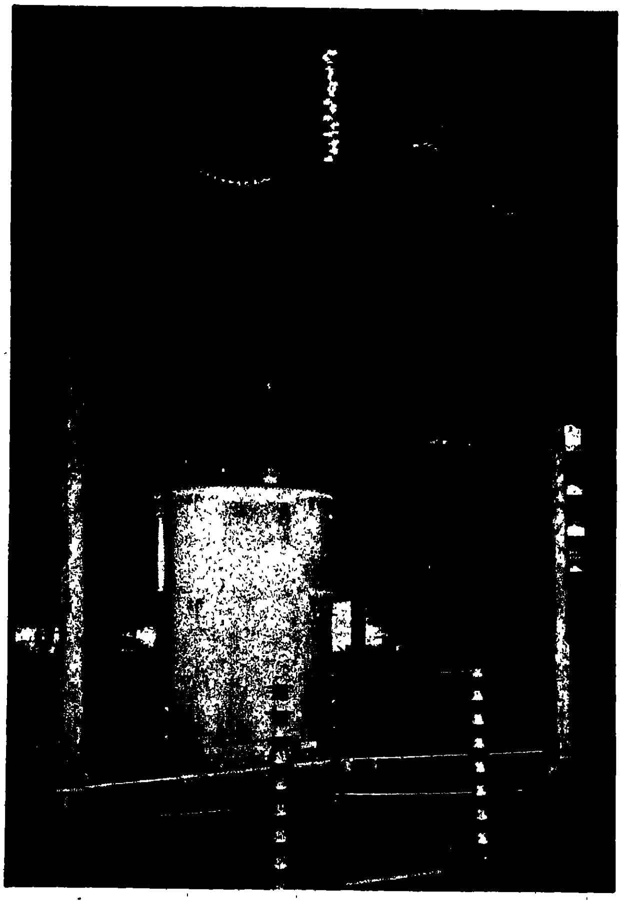
These tests are claimed to be significant for two reasons: first, that the transformers are by far the largest commercial transformers on which actual lightning tests have been made; and second, that the tests were much more severe than any heretofore applied to a commercial transformer. Each transformer was set up with a 64-in. protective gap, and connected to the surge generator with a short line supported by a string of fourteen standard insulator disks. The following tests then were carried out:

1. Several long-wave surges were applied to the transformer, the voltage being raised gradually until flashover of the protective gap took place.
2. The gap was then removed and long-wave surges of still higher voltage applied until the string of fourteen standard insulator disks flashed over.
3. The insulator string was replaced by one having twenty-one disks and the voltage increased until flashover of the transformer bushing occurred.

4. In order to simulate a direct stroke of lightning, a surge which rose to the flashover value of the protective gap was applied in a small fraction of a microsecond.

The first three of these tests proved that the requirements of coordination between the four elements, transformer insulation, bushing, line insulation, and protective gap, had been met. They also showed that the longest waves that could reach the transformer, even with an over-insulated line and no protective gap, produced no internal oscillations to overstress the insulation between the winding and ground.

The steepest wave front produced by natural lightning which has been recorded to date was found by Pittman and Torok (see ELECTRICAL ENGINEERING for July 1931, p. 494) to have a rate of rise of 4,000 kv. per microsecond. The wave front used in the fourth test above was nearly three times as steep as that measured by Pittman and Torok. It was thus proved that the transformer would withstand surges representative of the severe conditions of a direct lightning stroke on the line close to the apparatus. At no time during these tests did the transformer show any signs of distress. After the lightning tests were completed, the regular A. I. E. E. insulation tests were repeated as further evidence that the transformer had suffered no damage.



Flashover of line insulator with fourteen standard disks at approximately 1,300,000 volts

Relaying with Two Pilot Wires

The fastest relay scheme for isolating a faulty section of transmission line is the pilot-wire system. This usually requires four wires between stations, and therefore cost limits its application to short sections of line. A modified scheme is described herewith which reduces the number of wires needed.

By
C. H. FRIER
Oklahoma Gas & Electric Co., Oklahoma City

PILOT-WIRE RELAYING for transmission lines has the advantage of giving fast operation and of being independent of the setting of selective relays. With the usual definite time relays, the time settings of the relays must be increased in each successive section of line. This means that the section near the generating station frequently has such long settings that low-voltage conditions during faults on the system may exist long enough to drop synchronous equipment out of step. In certain cases, other forms of relays may be applied to obviate this difficulty, but the pilot-wire scheme is ideal from the standpoint of quickly isolating the faulty section of the line. It is especially advantageous in eliminating the difficulty of relaying on complex loops and networks.

The usual scheme of pilot-wire relaying consists of balancing the secondary currents of current transformers at both ends of the line. This requires four pilot wires between stations, and their cost usually limits the application of this scheme to short lines. The telegraphic pilot-wire relay scheme developed by the Oklahoma Gas and Electric Company requires one, or preferably two, pilot wires, and is therefore applicable to relatively long lines. It insures quick isolation on the occurrence of any type of line or ground fault where there is a source of power at both ends of the transmission line section. In addition to the pilot-wire relays the usual selective relays are used as back-up protection against the failure of the pilot wire. A supervisory system can be installed and is desirable to enable the operator to check the conditions of the telegraphic circuit at any time. Also, this circuit may be used simultaneously for telephone communication.

From "Telegraphic Pilot-Wire Relay System" (No. 31M13) to be presented at the A. I. E. E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

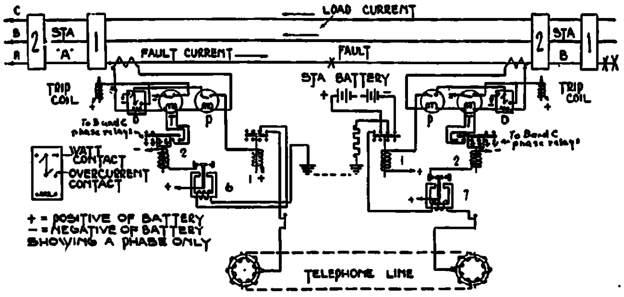


Fig. 1. Fundamental scheme of pilot-wire relay system

To remove hazards to life or equipment all current and potential transformers are grounded securely.

It usually will be more desirable for the operating company to lease the pilot wires from the telephone company than to own and maintain its own lines, as telephone wires strung on the high-voltage line towers are not feasible due to the high induced voltages; separate structures therefore are necessary.

The pilot-wire scheme consists essentially of directional and non-directional overcurrent relays at each end of the line, operating on low current flow into the section being protected. Current flow from either station into the line causes these relays to operate a transfer relay at the same station. The contacts of these transfer relays at both ends of the line are in series with each other through the pilot wire and ground return. The occurrence of a fault on the line section causes the current relays at both ends to operate, energizing both transfer relays, the contacts of which close the telegraph-wire circuit. Thus through auxiliary relays the tripping coils of the oil circuit breakers on both ends of the line are energized.

The details of the fundamental scheme are shown in Fig. 1, the current relays in phases *B* and *C* being identical to those shown for phase *A*. The watt contacts of the directional overcurrent *D* close when current is flowing away from the station bus. The overcurrent contacts of relays *D* are given relatively high current and time settings and form the secondary or "back-up" system. Relays *T* and *P* are overcurrent relays of the pilot-wire scheme and are given low settings. Upon the occurrence of a short circuit at *X*, the watt contacts on relays *D* and the overcurrent contacts on relays *P* at both stations *A* and *B* operate. This energizes transfer relay 1 at each station which closes the pilot-wire circuit through the operating coils of relays 6 and 7. These latter in turn energize relays 2 which remove the short circuits from the current coils of relays *T*. These are given instantaneous time settings, and current settings only slightly over the maximum load current so that when a fault occurs on the section and the short circuit is removed from the operating coils of relays *T*, both circuit breakers are tripped at the same time. Although only one pilot wire with ground return may be used, the use of two pilot wires and ground return as shown in Fig. 1 gives more reliable operation. These lines are usually leased in pairs, and by connecting them through a repeating coil at each end, satisfactory operation may be secured even with an open circuit on one line or a short circuit between lines, provided there are no grounds.

The purpose of the overcurrent phase selective relays *P* is to isolate the watt contacts of relays *D*. If the latter were connected in parallel, incorrect operation would result during certain cases. For example, if these watt contacts in each phase were not isolated and a short circuit occurred at *X X*, circuit breaker 1 at station *A* and circuit breaker 2 at station *B* would be opened. Considering the relays of circuit breaker 1 at station *A*, relay *P* and the watt contact of *D* in phase *A* would, of course, close due to fault current and energize the transfer relay at station *A*. Considering the relays for circuit breaker 2 at station *B*, load current would tend to close the watt contacts of relay *D* in phases *B* and *C*, and the contacts of relay *P* in phase *A* also would be closed by the fault current. It is apparent therefore that if these watt contacts were not isolated by relays *P* in each phase, the transfer relay would also be energized to complete the circuit through the pilot wire and trip the circuit breakers on the good section of line.

A lock-out scheme, the elements of which are shown in Fig. 2, further insures correct operation. The operating coil of multi-contact relay 8 is connected in parallel with that of transfer relay 1 of the switch on the opposite side of the same station. Relay 8 short-circuits the current coil of relay *P*. A fault at *X* which would cause circuit breaker 2 at station *A* to open would also energize lock-out relay 8 of circuit breaker 1 at station *A*, so that this latter circuit breaker could not open on through fault. This is desirable as the opening of circuit breaker 2 might set up transients which would close the watt contacts of the relays on circuit breaker 1. This condition would result if a synchronous condenser, a generator, or a transformer bank with the high-voltage side connected star and having its neutral grounded, were connected to the bus at station *A*.

A supervisory system, shown in Fig. 3, is used to give a continuous indication of the condition of the pilot

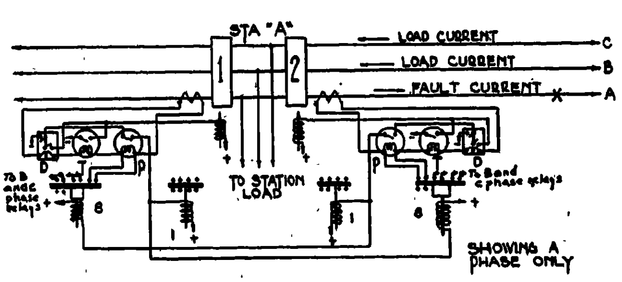


Fig. 2. Lock-out scheme of pilot-wire relay system

and wire to indicate operation of the equipment. Any operations of either the supervisory relay 4 or of the polarized relay 2 will give an indication on the recording voltmeter. The supervisory relay circuit is energized at all times unless the pilot-wire circuit fails or an operation of the transfer relay 1 occurs. Normally, the contacts of relay 4 are in the closed position and due to the resistor in the circuit the voltmeter reads slightly lower than battery voltage. If relay 4 is de-energized due to an open circuit or a ground in the pilot wire, the voltmeter will read zero and an alarm will sound. At station *B*, relay 3 will remain energized on a grounded pilot wire, but an increased reading on the milliammeter will result.

The telephone system by which the operators at two stations may communicate with each other is also indicated in Fig. 3. When it is desired to test the condition of the pilot-wire system the operators communicate with each other by telephone, and then operate the push-buttons in each station to cause both transfer relays to become energized. If there is no trouble on the pilot-wire system the alarm will sound.

Provision is made also for instantaneous clearing of a faulty section in the event of a substation operator closing a circuit breaker on a faulty line after the circuit breaker has tripped. This is accomplished by connecting the coil of relay 9 in parallel with the circuit breaker closing coil. Relay 9 is energized by pulling the closing button and then closes its contacts to remove the short circuit from the tripping relays *T*. If the current is abnormal, the switch will trip immediately without the assistance of the pilot-wire features.

One of the refinements which may be utilized is the use of a single pilot-wire installation protecting two parallel transmission lines. This scheme requires additional polarized relays which function only when current is flowing in one direction.

There are 193.5 mi. of actual telegraphic lines used by the Oklahoma Gas & Electric Company for the protection of its 66-kv. system. Over a period of five months, and during the most inclement weather, the total outages of the pilot wires amounted to 182.5 hr. or 36.5 hr. per month. During the first six months of 1931 there were 38 correct operations and only three incorrect operations. These were all caused by lightning closing the telegraph relays at one station while there was trouble on the adjacent section. Cycle counter tests have revealed that the entire equipment functioned in from 9 to 12 cycles, and with unvarying precision.

Although the telegraphic pilot-wire system is applicable to loops and networks only or where current is flowing into a fault from both directions, its use has been found to be justified by its quickness of operation on all types of line and ground faults. Since it is frequently necessary to lease wires from the telephone company for communication purposes, and the same wires can be used for the pilot-wire relay system, the additional expense in such cases is small. Another advantage is that where a power system is expanding rapidly, this pilot-wire relay scheme can be applied without rearranging the entire relay system.

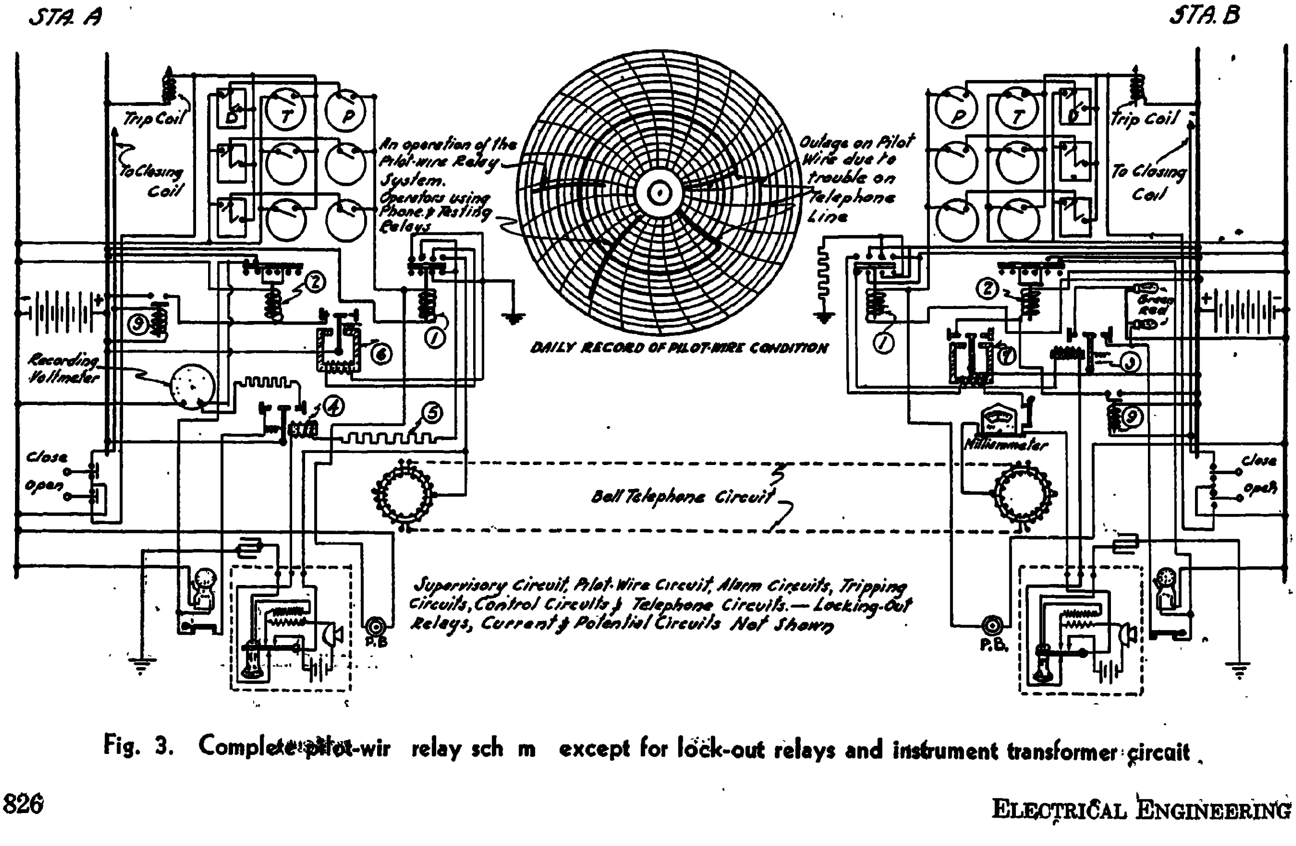

STA. A
STA. B
Trip Coil
To Closing Coil
D
T
P
An operation of the Pilot-wire Relay System.
Operators using Phone & Testing Relays
Outage on Pilot Wire due to trouble on Telephone Line
DAILY RECORD OF PILOT-WIRE CONDITION
②
①
⑥
⑨
④
⑤
⑦
③
Recording Voltmeter
Close
Open
Bell Telephone Circuit
Milliammeter
Green
Red
P.B.
Supervisory Circuit, Pilot-Wire Circuit, Alarm Circuits, Tripping Circuits, Control Circuits & Telephone Circuits.—Locking-Out Relays, Current & Potential Circuits Not Shown

Fig. 3. Complete pilot-wire relay scheme except for lock-out relays and instrument transformer circuit.

Experiments With Short Arcs

Observations were made on all phases of the arc discharge, including the transition period between the glow and arc stages. Current density at the cathode is shown to be the factor determining when that transition will take place, rather than the temperature of that element as was thought formerly.

By
G. M. SCHRUM University of British Columbia, Vancouver

H. G. WIEST, JR. General Electric Co. West Lynn, Mass.

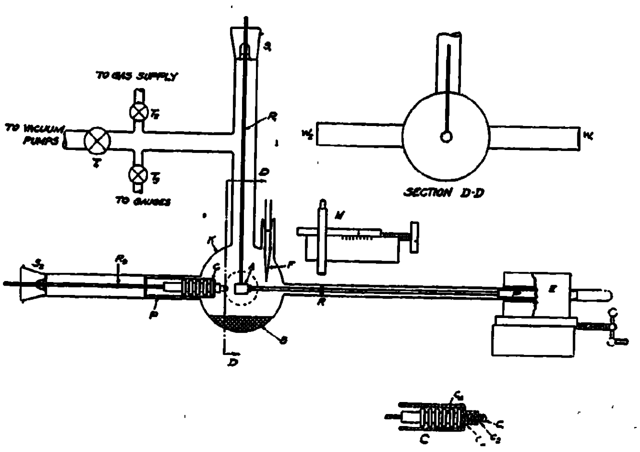


Fig. 1. Apparatus for studying the characteristics of low-current arcs in different gases

PHENOMENA associated with arc discharge between cold metallic electrodes are unusually complex, and in general not well understood. In view of the growing use of the arc commercially, especially in industrial welding operations, a further study of the physical mechanism underlying this particular type of discharge seems warranted. This investigation is concerned chiefly with short arcs (a few millimeters) between iron and copper electrodes in air and some of the inert gases, the gas pressures ranging from atmospheric to about 1 mm. of Hg. Particular attention has been devoted to the transition period between the so-called abnormal glow discharge and the actual striking of the arc.

Previous investigations have shown that this transition period is quite abrupt and many workers have doubted even the existence of such a transitory region. One common belief is that as the glow spreads over the electrode surface, the cathode gradually becomes heated sufficiently at some point to start an arc. In the present tests, however, a continuous transition was observed not only from the glow to the arc, but also in the reverse direction. The results indicate also that current density at the cathode rather than the temperature of that electrode is the factor determining when the transition takes place.

In the first series of tests a number of experiments were made on the arc discharge itself with currents ranging from 1 to 20 amperes. The arc current was supplied from a 250/500-volt d-c. generator, the current being adjusted by means of an external series resistance. In order to obtain reproducible results electrodes of approximately the same size and shape were used throughout, a convenient size having been found to be 1/8—3/16 in. in diameter and 2 in. long.

CHARACTERISTICS OF ARCS IN VARIOUS GASES

In this group of tests, results in general were found to agree fairly well with those of previous investigators. Steady arcs could be maintained in all cases in air or carbon dioxide, while in hydrogen, argon, and nitrogen, the arcs were either unsteady or would not strike at all. At lower pressures the arcs were less stable for all gases.

During some of the experiments, electrodes which had been used for arcs in air were found to give steady arcs later when used in argon. Further investigation showed that this phenomenon was due to oxidation of the electrodes when used in air, the same degree of arc stability being obtained in argon with electrodes oxidized by other methods. In addition it was found necessary to treat the cathode only; a stable arc could be maintained with a clean iron anode, and an oxidized cathode in argon and nitrogen, and also for a short time in hydrogen. With the electrodes reversed, that is, using a clean cathode and an oxidized anode, the arcs were unstable in these gases.

Further observation showed that when an arc was struck in various gases with the treated cathode, the cathode spot was established at the point where the electrodes had been in contact, and remained stationary; with the clean electrode this spot wandered so rapidly over the surface of the cathode that the arc soon broke. In order to investigate this characteristic further, a flat plate cathode was made, part of the surface of which was oxidized, the remainder being clean. When an arc was struck on the oxidized surface, it remained steady, but when struck on the clean surface it wandered as before but did not cross over on to the

---

From "Some Experiments with Arcs Between Metal Electrodes," (No. 31-14) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

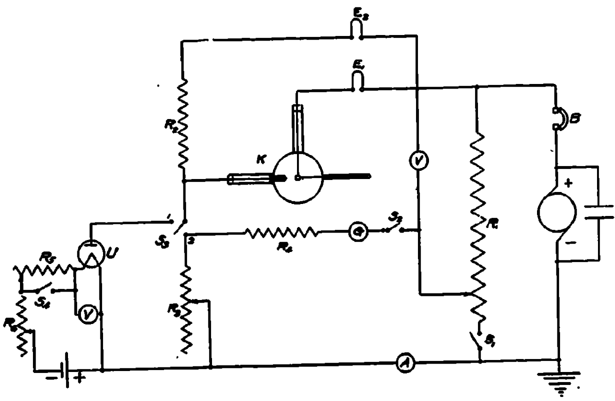


Fig. 2. Electrical equipment used in experiments on low-current arcs

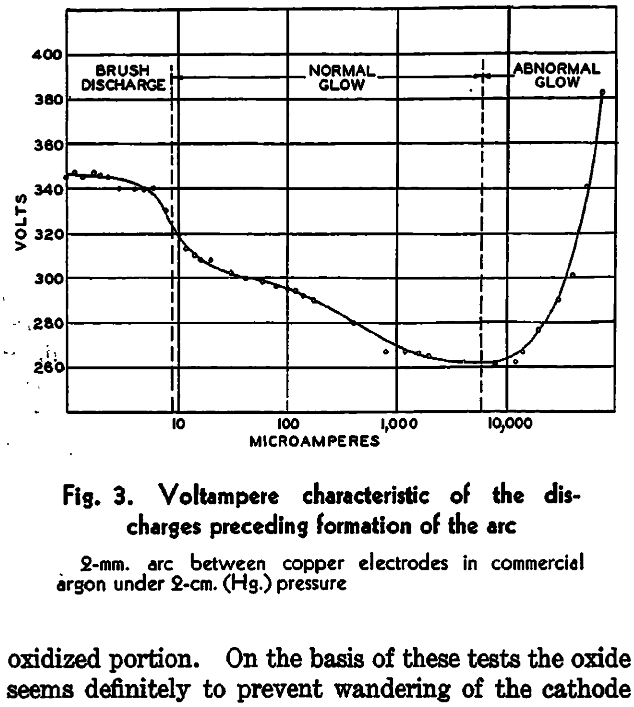


Fig. 3. Voltampere characteristic of the discharges preceding formation of the arc

2-mm. arc between copper electrodes in commercial argon under 2-cm. (Hg.) pressure

oxidized portion. On the basis of these tests the oxide seems definitely to prevent wandering of the cathode spot since other tests showed that this characteristic was not due to the roughness of the oxidized surface. This point is of particular note when it is considered that if the spot is prevented from wandering, the cathode temperature rises locally at that spot, and a steady arc results.

Tests in Dry and Moist Gases

In addition to the foregoing experiments, tests were made for the purpose of comparing arc characteristics in both dry and moist air and argon, respectively. Results of the tests in argon showed that the voltage drop across the arc in moist or argon was from 15 to 20 per cent greater than for the dry gas. Also the arc was found to be much more stable in moist than in dry argon especially at low currents, due perhaps to the oxidation which took place in the moist gas. Similar results were obtained for the tests in moist and dry air respectively, although the difference in arc drop was not quite so great.

The principal significance of the results of these particular tests is that if water vapor can be supplied to an arc used in welding the general effect would be to raise the potential drop of the arc, and thus for the same current increase the rate of melting.

To supplement the information already obtained, spectroscopic observations were made to determine which electrode contributed the greater amount of vapor to the arc stream. For this purpose a Hilger constant deviation glass spectrograph was used. Relatively low currents were employed for these experiments so that little or no fusion of the cathode took place. Results showed that the spectra in each case was typical of the cathode material although a few faint lines due to vapor from the anode were observed. The degree of excitation at the cathode thus is indicated to be much more intense than at the anode.

Transition Between Glow and Arc Discharges

In this portion of the study apparatus was arranged so as to enable the discharge characteristics to be observed between current values of 1 microampere and 2 amperes. A diagram of equipment used may be seen in Fig. 1, while Fig. 2 shows schematically the electrical connections. The arc chamber *K* consists of an 8-in. Pyrex bulb, electrodes being supported by the molybedenum rods R_1 and R_2 sealed in ground glass stoppers S_1 and S_2. To limit the area of cathode exposed to the discharge so that the region of the abnormal cathode glow might be explored properly, the cathode was made with two quartz protecting tubes C_2 and C_3, and with a large ribbed copper sleeve C_4 for cooling purposes. With this arrangement the cathode area exposed was about 0.22 sq. cm. The length of the arc gap was determined by a traveling microscope *M* with suitable scale, in conjunction with knife edge *R* attached to the rod of the soft iron plunger *P*. Glass beads *B* in the bottom of the bulb served to prevent drops of molten metal from cracking the glass. The heavy tungsten filament *F* serves to clear the bulb of all traces of oxygen in the argon.

For currents of from 1 to 100,000 microamperes switches S_1 and S_2 (Fig. 2) were closed. When the current values were such that the kenotron *U* was required, switch S_3 was in position 1; during those portions of the test in which the desired current variations could be obtained by external resistance S_3 was thrown to position 2. For currents from 0.05 to 5.00 amperes a UV-214 type kenotron was used, while for the lower currents a smaller three-element tube with grid and plate tied together was employed.

Arc-voltage readings were taken with various types of electrodes for currents varying from 1 microampere to 2 amperes. For this portion of the investigation observations were made on the galvanometer *G*.

Within this range of current it was possible to trace the development of the discharge from the corona or brush discharge through the normal glow and into the region of abnormal glow. A typical curve obtained from data taken in this manner for copper electrodes separated a distance of 2 mm. in commercial argon at 2-cm. (Hg.) pressure is shown in Fig. 3. Examination of this curve will reveal the fact that the volt-ampere characteristic is negative for the brush and normal glow discharges, becoming positive for the abnormal glow discharge. While the maximum voltage reached in the abnormal glow period varied somewhat an average value was of the order of 500 volts, and the corresponding current about 100 milliamperes. As the current was increased still further, the arc voltage decreased steadily until a drop of from 30 to 50 volts was reached, at which time the discharge exhibited all the characteristics of the true arc.

Due to the excessive heating of the cathode and of the protecting refractory material, difficulty was experienced in obtaining reproducible results within the transition region between abnormal glow and arc discharges. To overcome this difficulty, a large kenotron (UV-214 type) was employed for limiting the arc current, and an oscillograph was used to study the rapid changes occurring within this region, the two elements being connected as shown at E_1 and E_2 (Fig. 2).

To obtain the desired observations, the temperature of the kenotron filament was adjusted so as to give an arc current of about 2 amperes. The arc was then struck and switch S_4 (kenotron filament switch) was opened. As the filament temperature dropped, the arc current gradually decreased, the discharge passing through the various low-current stages. Oscillogram records were obtained simultaneously with this operation. Transition from the abnormal glow to the arc discharges was observed by starting with the normal glow discharge, then closing S_4, the kenotron filament switch; this gradually increased the arc current thereby causing the discharge to pass through the abnormal glow and into the arc stage, simultaneous oscillograph records being obtained as before.

A typical oscillogram showing the changes occurring between arc and abnormal glow is shown in Fig. 4 which was made with a short arc between copper electrodes in argon at a pressure of 25 cm. (Hg.). The duration of this experiment is indicated by the 60-cycle timing wave. In Fig. 5 is shown the volt-ampere characteristic plotted from the data given in Fig. 4. The transition from arc to glow was found to be quite abrupt. In other tests the transition from glow to arc was found to be practically identical and to take place at practically the same voltage and current values as the change from arc to glow. Since the time required for the kenotron filament to reach any particular value of discharge current must be different in the two cases, the transition would appear to be governed more by the cathode current density than by its temperature.

At lower pressures the transition between arc and glow was observed to be more gradual. This was true especially with short arcs. Thus it is quite obvious that both high pressures and long gap lengths tend to produce sudden transitions.

Results of these experiments indicate clearly the presence of a definite transition phase between the abnormal glow and arc discharges, although the volt-ampere characteristic for this stage is quite abrupt. Also current density at the cathode is shown to be the principal factor determining when this transition takes place rather than the temperature of that electrode. This contention is supported by other experiments in which the exposed area of the cathode was increased. In these, much higher currents were required before the arc could be developed, in spite of the fact that the electrode temperature occasionally was high enough to cause fusion.

An extension of this study of the transition from glow to arc and from arc to glow under various conditions appears to be a line of investigation which should lead to interesting results. An arrangement permitting the control and accurate measurement of electrode temperature especially that of the cathode, together with oscillograph records of the transition stages, should lead to a better understanding of the actual mechanism by which electrons are emitted from the cathode.

Fig. 4. Typical oscillogram for transition from arc to glow

1-mm. arc between copper electrodes in argon at 25-cm. (Hg.) pressure. Zero lines for voltage and current are indicated by V_0 and I_0, respectively

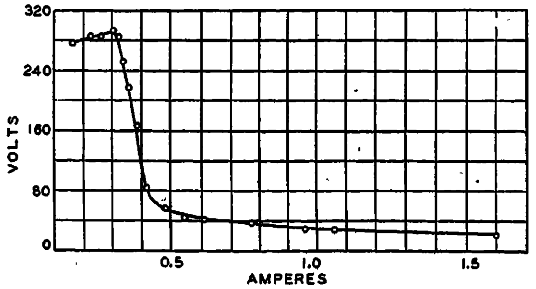


Fig. 5. Voltampere characteristic for transition period from arc to glow obtained from oscillogram shown in Fig. 4

Repulsion Starting for Capacitor Motors

The characteristics of single-phase motors are improved considerably by the addition of a capacitor winding on the stator. High torque and low current during starting also can be secured by the use of a repulsion type of rotor.

By
EDWARD BRETCH
Member A. I. E. E.

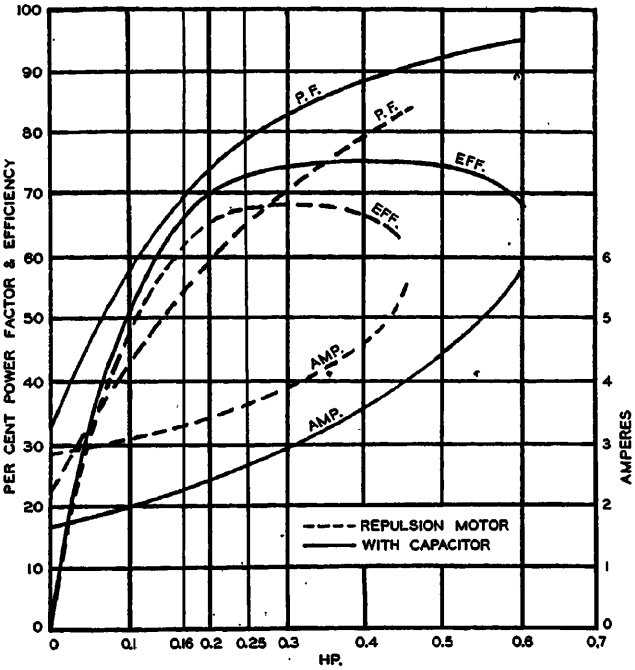
Advance Electric Co.
St. Louis, Mo.

THE DEMAND for single-phase motors with better electrical characteristics, together with the development of reliable and inexpensive capacitors, has encouraged the use of the capacitor motor. The stator of this motor has a second single-phase winding connected in series with a condenser and energized from the supply line. With this form of single-phase motor it is possible to approximate the efficiency and quietness of a polyphase motor, and at the same time to improve greatly the over-all power factor.

The problem of starting capacitor motors is about the same as in the case of single-phase induction motors without capacitor winding. Two general methods are available; the split-phase or rotary-field method of starting with a squirrel-cage rotor, and the commutator or repulsion method, in which the rotor currents are commutated for starting, and are short-circuited at running speed to operate as a squirrel-cage motor.

In the capacitor motors so far developed, split-phase starting and a squirrel-cage rotor have been used. With this means it is possible to use the capacitor winding as the split-phase winding during starting. Where a fixed condenser and a squirrel-cage rotor provide efficient starting torque, and the starting currents are not objectionable, this split-phase method of starting is desirable. However, where the locked rotor and low-speed torque must be exceedingly high, and heavy starting currents are objectionable, the repulsion method of starting has a considerable advantage over the split-phase method. Accordingly, an investigation was made of the practicability of a repulsion-starting capacitor motor; that is, a motor starting by the repulsion method but having a capacitor phase-winding on the stator.

The stator of a 1/6-hp. standard repulsion-induction motor was rewound for capacitor operation; the repulsion rotor was used for starting and then when up to speed was short-circuited in exactly the same manner as with the standard repulsion-induction motor. As shown by the curves, this capacitor winding had the effect of increasing the efficiency, power factor and output of the motor. Due to the increased efficiency, the capacitor motor operated at the same temperature rise at ¼ hp. that it did as a 1/6-hp. plain repulsion-induction motor, corresponding to about a 50 per cent increase in output. Also, it tended to eliminate noise, combining the better running characteristics of the capacitor motor with the starting characteristics of the repulsion-induction motor. Repulsion starting provides the same starting characteristics for the capacitor motor that it does for the plain induction motor, giving high locked-rotor torque with low locked-rotor current.



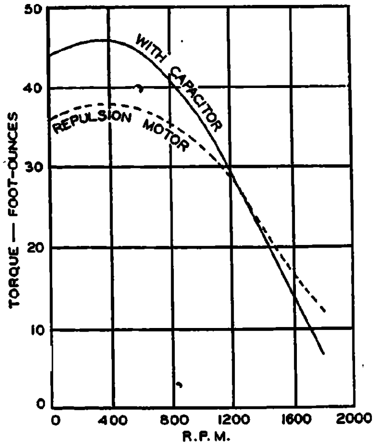
Characteristics of 1/6-hp. standard repulsion motor, and as rewound for a 1/4-hp. repulsion capacitor motor

Comparing a ¼-hp. repulsion-capacitor motor with a split-phase capacitor motor of the same rating, it was found that although the pull-out torque of the repulsion motor was less than that of the split-phase motor, and the full-load torques were the same, the locked-rotor torque of the repulsion motor was considerably greater. Also, the locked-rotor current and energy of the repulsion motor were reduced by more than half, and the full-load efficiency and power factor were increased.

Another advantage of the repulsion-capacitor motor is that a 7.5-μ f. condenser could be used in series with the capacitor winding for both starting and running, while the split-phase capacitor motor required a 7.5-μ f. condenser for running, and a 45-μ f. condenser for starting. In the event of condenser failure the repul-

---

Written especially for Electrical Engineering. *Not published in pamphlet form.*



Speed-torque curve of standard repulsion motor, and with a condenser connected permanently in the capacitor phase

sion-starting capacitor motor can still be operated as a plain repulsion-induction motor. Further, the equipment is fundamentally more substantial and reliable, as no overvoltage or surge is imposed upon the condenser at starting.

Considering both squirrel-cage and repulsion motors, together with their condensers and accessories, there is some question as to which will be the more costly. In the repulsion-capacitor motor, the extra cost of the capacitor winding is not so great as in the squirrel-cage capacitor motor, as in the former the condenser is of small size and can be connected permanently in the circuit, eliminating any automatic cut-out or the switches required for starting with the split-phase method. Although the addition of a capacitor winding increases the cost of a motor, the fact that a smaller motor may be used for a given output will in part, at least, overcome this extra cost.

On applications where the starting conditions on single-phase motors are severe, the repulsion-capacitor motor has a decided advantage over the other types and should be practicable on all sizes of motors, from the smallest to the largest.

Distribution Systems for Industrial Plants

THE PLANNING of an electric distribution system for industrial plants may be divided into two distinct parts: (1) determination of the electrical characteristics, and (2) the physical arrangement of the system. Under these two headings W. J. McClain (associated with Louis T. Klauder, consulting engineer, Philadelphia, Pa.) discusses the problem in a very general way in a current A. I. E. E. paper.

In designing the physical layout of the system, the author points out that the plot plan of the plant, together with present and future building plans, should be studied carefully. The manufacturing processes and equipment set up in the plant also should be studied, and a digest of system requirements compiled in order to arrive at a satisfactory solution for any particular plant. Single-line diagrams with arrangement sketches should be drawn for comparative solutions, ranging from maximum economy of design to maximum reliability or continuity of service. These diagrams may be amplified to include such features as voltage regulation, power-factor correction, and various types of switching equipment.

In conclusion the author states that a comparative tabulation of different solutions should be compiled showing relative costs, losses, space requirements, special building construction, efficiency of operation, continuity of service, and maintenance. This comparative tabulation reduces the various solutions to a basis from which a final solution may be selected, or a compromise effected to include desirable features of any of the solutions considered.

Electron Tubes for Industrial Control

ELECTRON TUBES have been in every-day use in radio and other communication fields for many years. It is only recently, however, that the field of application has been extended to include industrial usages, and while the gross number of industrial installations employing electron tubes is not enormous, important progress has been made in applying these new electrical tools to the problems of industry.

In a current A. I. E. E. paper, W. R. King of the General Electric Company, Schenectady, N. Y., outlines the fundamentals of operation and the practical aspects of the application of some of the more important of these new and interesting devices. Included in his discussion are the photoelectric tube, the three-element grid-controlled rectifier tube, and the grid-controlled mercury vapor rectifier.

From "Electrical Distribution Systems for Industrial Plants" (No. 31-29) presented at the A. I. E. E. winter convention, New York, N. Y., Jan. 26-30, 1931.

From "Electron Tubes in Industry" (No. 31-30) presented at the A. I. E. E. winter convention, New York, N. Y., January 26-30, 1931.

News
Of Institute and Related Activities

"Vacation Convention" a Noteworthy Success

VIEWED from every angle the twentieth annual Pacific Coast convention held at Lake Tahoe, Calif., August 25-28, was notably successful. The official registration was 247, not a record so far as Pacific Coast attendance goes, but notwithstanding exceeding many a similar gathering held in "better times." All technical sessions were called to order on scheduled time and were exceptionally well attended; discussions were widely participated in. Golf, boating, water sports, mountain climbing, trout fishing, and trips to nearby points of historic or scenic attraction were participated in according to personal preference.

Fully half of those present were "on their own time," taking in the convention as a part of a family vacation trip. This feature is significant in several ways and well may serve as a guide-post to those planning future conventions.

The technical program comprised four sessions accommodating 17 papers prepared by 25 men. Such of these as were not previously published in ELECTRICAL ENGINEERING in comprehensive form were abstracted in ELECTRICAL ENGINEERING, September 1931, pp. 753-6, and hence will not be treated here. Some of these papers were of strictly local interest, while others were of wider general interest; all were well received. Several of the papers provoked extensive discussion, both extemporaneous and written. On pp. 835-7 of this issue may be found a comprehensive abstract of the salient points covered by such of these discussions as were submitted to Institute headquarters within the prescribed time limit.

Two sessions devoted to their papers and a student breakfast conference drew many Enrolled Students to the convention. Papers presented at these sessions included:

SHORT-CIRCUIT CALCULATION, C. L. Holmes, State College of Washington.

LABORATORY STUDY OF TRANSMISSION LINES, D. J. Moore, A. A. Petrick and D. D. Johnson, University of Washington.

RESIDUAL CURRENTS AND VOLTAGES IN POWER SYSTEMS, C. A. Bairos and G. S. Kimball, Stanford University.

EFFECTS OF SHORT CIRCUITS UPON THE STABILITY OF A TRANSMISSION SYSTEM, S. G. Winkler, University of Southern California.

INFLUENCE OF PRESERVATIVES ON THE DIELECTRIC STRENGTH OF WOOD, C. B. Parsons and M. H. Tipton, Oregon State College.

SOME ELECTRICAL METHODS OF GEOPHYSICAL PROSPECTING, F. M. Holly, Jr., Montana State College.

VACUUM-TUBE VOLTAGE REGULATORS, E. W. Palmrose, University of California.

THYRATRON INVERTER, G. A. Ross and L. W. Russell, California Institute of Technology.

THE REFLEX THERMIONIC VOLTMETER, L. W. Thorpe, University of Santa Clara.

ACOUSTICS OF KINGSBURY HALL, F. Lundberg and F. N. Neal, University of Utah.

TORQUE ANGLE CHARACTERISTICS OF SYNCHRONOUS MOTORS, W. F. Arndt, California Institute of Technology.

SOUND PICTURE SYSTEMS, Charles Douglas, University of Nevada.

C. E. Grunsky of San Francisco, Calif., president of the American Engineering Council, presented the feature address of the convention at a general session held the evening of August 26. Men and women alike paid close attention to this dissertation on "Business Cycles and Some Economic Problems" in which the speaker's penetrating insight and rare personality enabled him to present in a most interesting and illuminating fashion some of the fundamental causes underlying the recurring cycles of business activity. The speaker reviewed the situation rather comprehensively saying relatively little directly concerning the current economic disturbance, but pointing out the striking similarity existing between the current depression and those which have occurred periodically during the past century.

Having established the fact that history repeats itself so strikingly approximately every 20 years, Mr. Grunsky mentioned several important contributing factors including human shortsightedness and taxation inequalities, stressing the unfairness of our present political tax bonus system. He discussed also the rigid and destructive inflexibility of the dollar (or any other unit of money) as a measure of value where the element of time enters into a given transaction, presenting statistics revealing the varying purchasing power of the dollar (or any other money unit) during the past century. He suggested and strongly urged that with the present system of money as an exchange medium, and with a "commodity unit" to serve as a basis of evaluation supplementing the money unit, many evils now commonly encountered would be obviated. With the use of the commodity unit or "com" as a basis of valuation, the sale of services or commodities involving a period of time would be made on an agreed basis of so many "coms," thus assuring for buyer and seller an equitable deal. Payment of course, would be made in dollars or any other normal money unit according to the relation existing at the time of payment between the "com" and the money unit.

Of course, the principal sporting event was the annual golf tournament for the John B. Fisken perpetual trophy. Some 60 entrants enjoyed keen competition in three classes for the large group of valuable prizes. Honors for the day went to M. S. Barnes (M'31) of the San Francisco Section who by virtue of his low net score of 61 (78-17) captured the Fisken Trophy and a set of six matched irons. Others who shared in the prizes were G. R. Murphy (F'20), W. G. B. Euler (A'08), W. L. Winter (A'21) and Nathan Cohn (A'29) of the San Francisco Section; and C. C. Boozier (A'23) of the Portland Section. Kickers' prizes went to G. M. Rosenblatt (M'17) San Francisco Section; David Hall (F'18) Los Angeles Section; and C. C. Boozier (A'23) Portland Section. Honors in the women's putting contest went respectively to Mrs. A. V. Thompson and Mrs. A. G. Jones, San Francisco; Mrs. L. C. Williams, Los Angeles; and Mrs. D. M. Peterson, San Francisco.

The reception for President Skinner and the convention banquet constituted the two formal social affairs. A tremendously successful barbecue dinner held on the Tahoe Tavern tennis courts, and enlivened by the Neapolitan Trio of radio fame, introduced a series of informal social affairs very apparently enjoyed by all. The final event was "A Night in Monterey," a Spanish cabaret put on by the Tavern management.

Other entertainment features included a women's bridge tea, a three-hour steamboat trip down Lake Tahoe to scenic Emerald Bay, a presentation of Will Rogers's "Connecticut Yankee," and a playlet "What's the Use?" presented by local talent under the direction of A. C. Joy, San Francisco, depicting humorously the overthrow of a trained and established engineer by a correspondence-school graduate who had a diploma certifying to his mastery of engineering via a 90-day course.

President Skinner Traces Trend of Electrical Engineering

The convention was formally opened by General Chairman A. W. Copley promptly at 9:30 a. m. August 25, with a full attendance. Mr. Copley introduced Dr. C. E. Skinner, president of the Institute, whose opening address sketched, decade by decade, the trend of thought in electrical engineering as represented by the published record in the A. I. E. E. TRANSACTIONS. Excerpts from Doctor Skinner's address follow:

"The Institute's first meeting was held in Philadelphia in October 1884, and the first paper found in Vol. 1 of the TRANSACTIONS is by Dr. Edwin J. Houston on 'Phenomenon' now known as the Edison effect. . . It seems to me quite fitting that the first paper published should refer to work of Thomas A. Edison, the pioneer in incandescent electric lighting as well as in so many other fields.

"Curiously enough in this same volume is found a paper on a system for placing wires under ground and providing subways for electric traction under the streets of New York; another with the curious title 'The Earth as a Circuit Completer.' Attention is given to multiplex telegraphy and to electroplating; and very considerable discussion is recorded of the inadequacy of the patent office to deal properly with electrical inventions. I have heard this same discussion in recent years. In this discussion it is stated that prior to 1880 there were fewer than 2,000 patents recorded in the United States Patent Office having anything whatever to do with electricity.

1884–1890

"Subsequent volumes of the TRANSACTIONS between 1884 and 1890 contain some extremely interesting papers on various subjects. . . For example, in Vol. 4, 1887, appears a paper. . . 'Distribution of Electricity by Secondary Generators' outlining schemes with which my own more than 40-year career has been intimately associated. This paper was the announcement before the Institute of the a-c. system espoused by George Westinghouse and outlining the Gallard-Gibbs scheme of what we now know as the a-c. system of distribution by the means of transformers. . . Another paper which excited my interest, and some amusement, was a long paper, followed by a very extended discussion, on 'A New Arc Lamp Clutch.' It is also noteworthy that the men of prominence of that time referred to themselves and each other as 'electricians' and not as electrical engineers, and one wonders how it came about that the original name of our organization was chosen as the American Institute of Electrical Engineers. While I have not read carefully, I do not recall seeing the term 'electrical engineer' used in any of the volumes prior to 1890.

"The period from 1884 to 1890 was of course the real pioneer period of both the Institute and the electrical industry. It was a period of cut-and-try methods. The term 'industrial research' had not been coined, but even so, relatively great advances of this period can be assigned to relatively few experimenters, most of whose names appear in the Transaction of the Institute, and in many cases as past-presidents of the Institute. It was during this early period that the first limited electric light plants were installed and operated, and the electrification of street railways begun. . . A paper read in 1886 states: 'The central station of today is a very large and cumbrous arrangement. There are many engines in rapid motion and exposed to many dangers and interruptions. There is an air of gloom and anxiety on every face. The unseen tremendous power, not always under control, which is consumed at uncertain times and at invisible points, may be made to react at any moment with destructive energy.'

1890–1900

"The period between 1890 and 1900 was one of exceedingly rapid development and betterment in the design of electrical machinery, the means of measuring electric current, and the rapid extension of central stations and isolated electrical plants in buildings and factories. The TRANSACTIONS of the Institute reflect these advances and contain the fundamentals of the history of the electrical developments of the period. . .

"It was during this period that the great project of Niagara Falls came to fruition with the transmission of great amounts of power to more than twenty miles, and this was really the beginning of electric power as a commodity. The Tesla polyphase a-c. motor had been announced prior to 1890, but it was only during this decade that the polyphase motor became a commercial product. In the early nineties means of measuring alternating current were very unsatisfactory; the best instruments of precision we had for this purpose when I entered the Westinghouse laboratories were the Cardew hot-wire voltmeter and the Siemens electrodynamometer for current. However, much more satisfactory instruments appeared before the end of the decade. It was during this period also that the first high-voltage transmission plants were constructed in the West, the first of these being the so-called Pomona (Calif.) transmission at 11 kv.; and it is interesting to note that due to our lack of experience in the building of high-voltage transformers we used twenty 110/550-volt transformers with secondaries in series and primaries in parallel. The modern street-car motor in all of its essential principles appeared. . . in the summer of 1890. . .

1900–1910

"The next decade, from 1900 to 1910, was characterized by extremely rapid extension of electrical plants throughout the world, and the development of larger and more efficient electrical machinery. . . more efficient prime movers, particularly the steam turbine. . . It was the heyday of the street railway, and it was during this period that many important inventions. . . appeared. One of these which has had a profound influence was the development of silicon steel. Prior to the middle of this decade, electric steel was merely a refinement of the steel used for other purposes, and the losses particularly in transformers were giving a great deal of trouble. . . By the end of 1906 silicon steel, invented by Sir Robert Hadfield of England, was in general use both in this country and abroad, and the intrinsic loss had been cut in half and aging entirely eliminated. Many refinements and improvements have been effected since that time and much of the history of the magnetic art may be found in our TRANSACTIONS. Through the reduction of losses in electrical apparatus by the use of this steel hundreds of thousands of tons of fuel have been saved.

"One of the subjects which might be dealt with in a paragraph in any of the decades from 1900 to the present time is that of lightning protection. While I have not checked pages it is my belief that there are perhaps as many, possibly more, pages in our TRANSACTIONS devoted to lightning phenomena and lightning protection than any other single specific subject. . . It may be asserted, however, that. . . even in the beginning of the present decade, 1930 to 1940, the complete and final solution of lightning protection is yet to be effected.

1910–1920

"The period from 1910 to 1920 was a period of the further expansion of electrical plants, the further increase in the output and efficiency of electrical machinery, and the real beginning of the use of electricity in household devices and in industrial heating. The automobile had begun to take toll from interurban traction, and to a certain extent from city traction lines. In the previous decade electrification of the steam railways in congested areas had reached considerable proportions, and the old a-c.-d-c. battle was fought over again in connection with heavy electric traction. . . The mercury-vapor converter had entered as a factor, particularly in Europe, and at the same time the rotary converter had been brought to a very high degree of efficiency and perfection. . .

1920–1930

"The decade from 1920 to 1930 certainly may be characterized as the period of consolidation and interconnection. . . It may be of interest to note here that after a study of transmission made during my senior year in college (1889-1880) my class definitely proved that electrical transmission of light and power never would be profitable to a distance of more than five miles. We now transmit power by the a-c. system, then almost unknown, in very large quantities many hundreds of miles, and sooner or later we no doubt will be interconnected in our plants from the Atlantic to the Pacific. . .

". . . We are just as much interested, (and perhaps more so) in the future as we are in the past. Both the manufacturers and the utilities now have research departments intensively engaged in attempting to peer into the future, and in devising new applications, new materials, and new equipment. They are carrying on much fundamental research, many times with no immediate hope of commercial returns. . . It would be a bold prophet who would predict that radically larger units, more efficient prime movers, or better transmission systems would not be forthcoming; but for the present we seem to be more or less at a standstill in this line. The use of household devices is certainly on the rapid increase. . . One of the extremely interesting developments now going on is that of air-conditioning in our homes and offices, and even in our workshops and trains. . .

"I have not even mentioned some of the most sensational developments that have been made in fairly recent years, such as radio.

"We electrical engineers have been accredited, or perhaps accused of being responsible, along with other branches of engineering, for our present depression through our making it possible for the individual worker to produce much more than by older methods. It is certainly true that the machine age has brought us a host of problems that must be solved by us or by our children. As engineers we must go forward as we have in the past, bringing greater efficiency, greater comforts, more commodities, and greater production by the individual workmen. As citizens we must do our part in bringing the same sort of efficiency to our local state and national government. We must humanize our engineering. Surely some of the evils of today should yield to analysis and cure by the same general methods which have proved so effective in solving the multitude of far-reaching difficulties that have beset us as electrical engineers in the years compassed by our American Institute of Electrical Engineers.

Last Call for Kansas City Meeting

Kansas City, Missouri, host city to a three-day meeting of the South West District No. 7 of the A. I. E. E., has completed plans which will provide both a profitable and enjoyable time for those in attendance, October 22-24. Headquarters will be at the Kansas City Athletic Club.

Four technical sessions will be held during the meeting. These should prove of particular interest to the utility planning engineer as well as the utility operating engineer and all who are engaged in telephone communication work. In connection with the St. Louis-Bagnell interconnection session which will be held on Thursday evening, a three-reel motion picture of the actual construction of the Bagnell dam will be shown.

The local committee has arranged a variety of inspection trips to points of unusual interest embracing up to date electrical applications. Some of these features consist of new supersynchronous motor installations for the cement mills, the completely automatic distribution system of the Kansas City Power and Light Company, automatic installation of the Southwestern Bell Telephone Company, and the Bagnell water power project.

The chief social event of the meeting—the meeting banquet—will be held on Friday evening, Oct. 23. Entertainment will be provided by some of the best talent obtainable and following the banquet there will be dancing. Special plans have been made to care for women guests.

A detailed program of this meeting, together with a list of the papers to be presented, was published in ELECTRICAL ENGINEERING, September 1931, pp. 757-9.

District Executive Committees Meet at Tahoe

A business meeting of the combined executive committees of Districts Nos. 8 and 9 and the western portion of District No. 10 (Canada) was held at Tahoe Tavern, Lake Tahoe, Calif., August 26, 1931, as a luncheon gathering. Those present included: *president*, C. E. Skinner; *national secretary*, F. L. Hutchinson; *vice-presidents*, H. V. Carpenter and A. W. Copley; *District secretaries*, C. E. Baugh and R. D. Sloan; *Section chairmen*, E. A. Crellin (San Francisco), P. S. Biegler (Los Angeles); *other Section representatives*, W. C. Smith (San Francisco), H. W. Hitchcock (Los Angeles), O. B. Coldwell (Portland), C. B. Carpenter (Seattle), J. H. Hamilton (Utah), H. T. Plumb (Utah), F. W. MacNeill (Vancouver, B. C.), and J. A. Thaler (Montana).

The first order of business was the assignment of the 1932 Pacific Coast convention which was awarded to the Vancouver (B. C.) Section with the dates tentatively set as August 29-September 2 inclusive. The 1933 Pacific Coast convention was tentatively awarded to the Utah Section.

Student participation in future conventions was a subject which aroused thoughtful and active discussion. Based upon experience with the Lake Tahoe convention, E. A. Crellin, the new chairman of the San Francisco Section, strongly urged that for future Pacific Coast conventions the usual convention committees be augmented by the addition of a "committee on student participation." Mr. Crellin suggested that the duties of such a committee should include primarily (1) attention to the question of suitable housing for students in attendance at the convention, and (2) assisting in and coordinating the work involved in the handling of student sessions, the securing and advance circulation of student papers, and the stimulation of discussion at student sessions by the choosing of "key" men to start such discussions.

Student Activities Discussed at Lake Tahoe

At a student activities conference held in connection with the Lake Tahoe convention August 27, and presided over by G. L. Hoard, student counselor, University of Washington, Seattle, several problems pertaining directly to the conduct of these student conventions were discussed. Concurrent student sessions were considered undesirable. A motion was passed authorizing next year's committee to select student papers on a competitive basis (rather than by allotment to schools as at present) such competition to be effective only after each Branch had been given an opportunity to present one paper for consideration. Arising out of a discussion of the problem of getting student papers in in time for intelligent selection, a motion sponsored by the students themselves was put through, urging the establishment of a definite deadline date for student technical papers.

As a result of discussions pertaining to the several problems involved in publishing, or otherwise reproducing in some reasonable quantity, the officially accepted student papers, it was suggested by several that either the student Branches themselves, or the educational institutions with which they were affiliated might provide the necessary finances for this work. Other questions discussed included ways and means of getting before high school students authentic vocational guidance information pertaining to electrical engineering courses, and possible methods of enhancing student interest and student participation in Branch activities.

Out of the fourteen student Branches of the Institute in Districts Nos. 8 and 9 and the western half of District No. 10, thirteen were represented at this student activities conference. Twelve of the student chairmen were present (representing all Branches except those at the University of Nevada and the University of British Columbia) and nine of the student counselors were present. Student counselors present included: F. O. McMillan, Oregon State College, S. G. Palmer, University of Nevada, O. E. Osburn, State College of Washington, R. H. Hull, University of Idaho, W. G. Angermann, University of Southern California, J. H. Hamilton, (for A. L. & R. Taylor) University of Utah, R. W. Sorensen, California Institute of Technology, L. E. Reukema, University of California, and E. F. Peterson, University of Santa Clara (Calif.). Student chairmen present included: M. R. Jones, Jr. Stanford University, R. C. Hansen, University of Utah, D. H. Hansen, Oregon State College, P. F. Hawley, University of Arizona, A. S. Koch, University of Washington, G. E. Gage, University of Idaho, H. T. Lambdin, Montana State College, D. H. Olney, State College of Washington, P. B. Lyons, California Institute of Technology, V. T. Johnson, University of California, M. C. Marshall, University of Southern California. and L. W. Thorpe, University of Santa Clara.

Summarized Review of Some Pacific Coast Convention Discussions

ONLY discussion submitted in writing in accordance with governing A. I. E. E. rules is summarized; complete discussion together with all approved papers will be published in the TRANSACTIONS. Abstracts of all papers presented at the convention and not previously treated in ELECTRICAL ENGINEERING, were given on pages 753-6 of the September issue.

INDUSTRIAL APPLICATIONS

G. B. Rosenblatt (San Francisco, Calif.) discussed the economic side of "Electric Power in the Wood Products Industry." He explained that increasing taxes on standing timber had caused an over production in lumber which allowed but little or, in come cases, no margin of profit. Therefore, in order to realize a profit the industry will turn toward an increased number of fabricating processes and more uses of the wood waste, both of which will result in a greater consumption of kilowatt-hours.

K. M. Patterson (East Pittsburgh, Pa.) also discussed this paper with special reference to the application of synchronous motors. He pointed out that in the sizes used in the lumber and paper industries synchronous motors usually represent a savings in first cost over other types of motors, with the additional advantages of high efficiencies and controlled power factor. He also explained that the development of full magnetic control with adequate protective features had kept pace with the improvement of motor characteristics.

R. O. Brosemer (San Francisco, Calif.) and J. L. Wright (Portland, Ore.) discussed this paper and pointed out that their experience based on a number of actual surveys made in typical sawmills in the Pacific Northwest indicated that electric power consumption varied from 45 kw. to 60 kw. per 1,000 board feet. Another point brought out by them referred to the possible inference in Table II that synchronous motors should be used for all main drives in modern sawmills, and induction motors only for secondary drives. Notwithstanding the advantages and improvements in synchronous motors they felt that due to their simplicity and usually lower first cost, there was still a legitimate field in induction motors for such main drives.

David Hall (Los Angeles, Calif.) discussed "Electrical Equipment for Oil-Field Operation" referring to the progressing evolution from steam to electricity. He told of recent improvements made by his company regarding mud-pump drive. These consisted of wound-rotor induction motors with permanent resistance and reactance in the rotor circuit, an arrangement which provides a motor which will slow down under increasing loads and actually stall before the pumps can be injured. He also explained that rotary drilling using a completely electrified rig of the Hild differential type recently successfully completed the deepest well in the world, drilled to a depth of 10,030 ft. He further explained that d-c. equipment was developed to meet the demand for drilling "wild cat" wells.

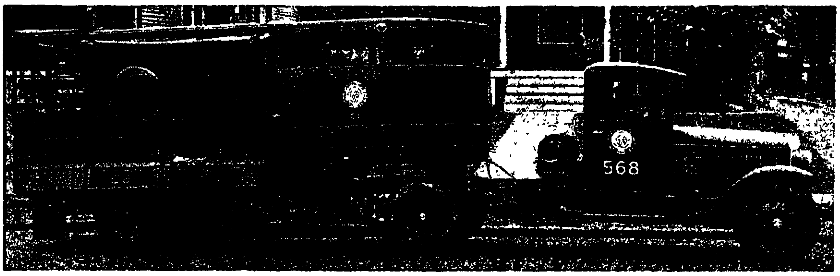
ELECTRICAL MACHINERY

P. L. Alger's (Schenectady, N. Y.) discussion of "Correlation of Induction-Motor Design Factors" was presented by J. H. Cunningham (Los Angeles, Calif.). Mr. Alger drew attention to the magnitude of the task and said that he believed it was theoretically possible and very desirable, to express all the electrical and mechanical constants of a motor, and lso its cost, as explicit functions of its principal dimensions. Thence the optimum values of all dimensions could be determined for any desired evaluations of cost and performance.

R. E. Hellmund's (East Pittsburgh, Pa.) views on this subject were presented by David Hall. He pointed out that the designer usually is forced by many practical conditions to depart from the ideal, and that the author's method had the same limitations as all other methods of analyzing and carrying through design work by a simple set of formulas. If all essential considerations are taken into account, the method becomes cumbersome or else numerous assumptions have to be made which do not properly take into account all factors of practical importance. The second fundamental assumption in the author's theory used the ratio of the flux densities in the teeth and the core. Mr. Hellmund did not believe that the choice of this factor as an important variable was particularly desirable because this ratio did not represent anything very basic in the design of the motor. It can be, and frequently is, varied over wide limits without materially affecting the final results.

G. E. Creed and R. J. Thompson (Hamilton, Ont.) in their discussion of this subject which was presented by V. B. Wilfley (Portland, Ore.) called attention to several pertinent considerations including power factor (especially on slower-speed motors), iron losses, ventilation, proportion of length of coil ends to active length, starting current, starting and pull-out torques, and the necessity for using commercial wire sizes. They pointed out that these considerations usually would require an appreciable departure from the theoretically best dimensions which give minimum stator resistance in order to obtain a good practical design.

New Type of Truck for Line Crew



ADDED to the motor fleet of the Cleveland (Ohio) Electric Illuminating Company is a new unit which has proved so satisfactory that a second is being built. The vehicle is designated as a "tractor-type semi-trailer" and is constructed so that the trailer can be detached and left at the scene of an operation, while the tractor is free to engage in such transportation work as may be required. Its fully enclosed cab provides comfortable seats for twelve men, well safeguarded against traffic accidents. There is ample space within the body for all sizes of tools, the compartments being arranged so that the tools most frequently used are on the outside. The unit is of all-metal construction, sturdy and weatherproof.

A. H. Barth's discussion of this paper was presented by R. W. Sorensen (Pasadena, Calif.). It explained that the author has been given an opportunity by an electrical manufacturer to try his method of analysis in the laying out of new designs and adding larger sizes to older lines where the dimensions of the component parts could be made any value which would give the most satisfactory motor and not be governed by the necessity of adapting a particular motor to an existing frame. The author has been very successful in this work and the paper is the result of his having filled the need for simple manner of determining optimum motor dimensions mathematically instead of by the rather empirical methods which now are in general use.

R. W. Sorensen also discussed this subject explaining that the Hoover analysis enables one in the early stages of design, to consider mathematically, and thus accurately, more of the variables which have to do with the relations between punching diameters both internal and external, core depth, and slot dimensions, thus reducing the element of guess work, and making possible a more accurate selection of the rating to which a given punching is best adapted.

E. A. Crellin and F. I. Lawson (San Francisco, Calif.) discussed "Calorimeter Measurement of Stray Load Losses on Generators." They analyzed test methods to determine stray load losses and presented data on generator losses obtained by the retardation method from efficiency tests made on a number of hydroelectric units. They cited that the information presented by the authors, giving an independent determination of stray load losses, was a distinct contribution to the hydraulic as well as to the electrical engineer.

Power Transmission and Distribution

J. W. Bennett's (Springfield, Mass.) discussion of "A-C. Networks in Portland, Oregon" was presented by G. Ross Henninger (New York). The discussion drew attention to the cost of the duplicate primary system adopted in Portland, as compared with the system having a radial primary and network secondary. The discussor cited several local conditions each of which would be variable in different localities, and stated that these of course would influence the design and development of a distribution system. He believed the difference in favor of the system adapted was due to conditions existing in Portland. Results of a recent comparative study made by J. W. Bennett were in favor of a low-voltage network system supplied at 13-kv. secondary transmission voltage for areas having a well distributed load of 5,000 kva. per sq. mi.

H. S. Fitch's (Pittsburgh, Pa.) discussion of "Tie Line Control of Interconnected Networks" was read by S. B. Clark. The discussion told of the operating problem of the Pennsylvania-Ohio-West Virginia interconnection from the early beginning up to the present time. Tie line control on this interconnection first was attacked from the point of view of frequency control.

Nathan Cohn (San Francisco, Calif.) presented Philip Sporn's (New York) discussion of this subject which reviewed the problem as related to the operation of interconnected systems. It was the experience of Mr. Sporn that automatic frequency control on each of two systems operating on parallel has been found to reduce greatly the fluctuation on a tie line, and in one instance it was the only practical means of operating the systems in parallel through a relatively weak tie line. This statement is contrary to the findings in the paper discussed.

P. B. Garrett (San Francisco, Calif.) presented a discussion prepared by John Gosinski (Jackson, Mich.) which drew attention to the operation of tie-line load regulators. It was pointed out that the purpose of an interconnecting tie line was to transfer large blocks of power in an emergency, and that any regulating device should preserve this feature of an interconnection.

Dr. W. A. Lewis (East Pittsburgh, Pa.) presented Robert Brandt's (Boston, Mass.) discussion of this paper which also brought out the necessity of frequency control as a step in the solution of the major operating problem. He believed the mechanical devices described in the paper had been well thought out and that they serve their purpose admirably. In particular, reference was made to the explanation of the anti-hunting feature which takes into account the momentum that has to be established and later destroyed in bringing the system from one load condition to another.

A discussion by Edith Clarke (Schenectady, N. Y.) on "Tuned Power Lines" was read by G. Ross Henninger. By means of vector diagrams, Miss Clarke arrived at the same results as those expressed by Professor Skilling in his paper, (that a transmission line of wavelength slightly over a half wave, including the terminal machine impedance, has good operating characteristics and that power may be exchanged between a synchronous generator at one end of such a line and a motor at its other end, while for the line slightly under half wavelength little or no synchronous power can be transmitted).

Communication

G. T. Rouden (San Francisco, Calif.) discussed "Intercontinental Radiotelephone Service from the United States," explaining that the International system had circuit in operation handling telegraph business between New York and Madrid via Buenos Aires. This avoids the difficulties experienced with an east-west circuit such as that over the North Atlantic. He also mentioned the downward trend in the cost of long-range antenna systems. The high steel tower construction used during and just following the war period now has been superseded by the simple double-V antenna supported by common wood poles only 70 ft. high. The new and less costly construction provides efficient operation over a wide range of frequencies and is expected to make feasible the extension of communication facilities to many localities which otherwise could not be reached economically.

P. G. Caldwell (Stanford Univ., Calif.) discussed "Electrical Measurement of Sound Absorption," explaining that when sound energy is "absorbed," it is converted into heat energy by a process which involves a friction between the absorbing material and the oscillating air particles. Therefore sound-absorbing material will be most effective when it is placed where the air particles are oscillating with maximum velocity. This position always is a quarter-wavelength distant from a sound radiator or hard reflecting surface. The data in Fig. 5 of the paper are not in accordance with the foregoing explanation. Possibly one reason for the apparent discrepancy lies in the fact that the radiator was a dynamic loudspeaker. There is some question as to what point on the loudspeaker cone should be considered as a reference when taking data such as that in Fig. 5.

ELECTROPHYSICS

H. H. Skilling (Stanford Univ., Calif.) discussed "The Kindling of Electric Sparkover" quoting similar conclusions from a report of a study made at the Ryan laboratory. These conclusions concerned superposed 60-cycle and impulse phenomena between points; they supported the three conclusions in the paper.

S. S. Mackeown (Pasadena, Calif.) discussed the theory of the spark discharge to show just what is difficult to understand today. He referred to the early theory of Townsend's and the work of Rogowski and others which found that the time necessary for a spark discharge to occur was of the order of 10^{-8} sec. He explained that the pictures in Doctor Magnusson's (Seattle, Wash.) paper were a record of what occurred probably of the order 10^{-5} sec. Therefore it would seem dangerous to draw conclusions regarding the actual formation of a spark from the data presented in that paper.

RADIO COORDINATION

J. J. Smith's (Schenectady, N. Y.) discussion of this subject was presented by C. F. Green (Schenectady.) He cited several points which showed that the question of responsibility is more involved than would be assumed from the three last paragraphs in the section entitled "Responsibility" in the paper. He believed the work done by the authors would be of considerable value if carried out in quantitative manner so that measurements in one locality could be compared with those in another.

J. O'R. Coleman (New York) interestingly discussed this problem and drew attention to the question of definition of interference as applied to radio. He referred to the study of the coordination of power and telephone systems, which revealed that the problem naturally divided itself into a study of power system influence, coupling between the two systems, and susceptiveness of the telephone system. He believed the same treatment could be applied in the handling of radio coordination. It was explained that a joint committee of representatives of the R.M.A., N.E.L.A., and N.E.M.A. had been formed to study the problem.

F. B. Doolittle (Los Angeles, Calif.) discussed this subject emphasizing the need for a better distribution of broadcast coverage in California. He showed a map of the state in which the areas enjoying reasonably good reception were designated and might be compared with the total area of the state. It was believed California had a sufficient allotment of broadcast power and frequencies to serve the area adequately, but that the geographical distribution of stations was not good. Reliable service is not available to large areas while inconvenience is worked upon other places by an excessive number of stations.

Nomination of 1932 Institute Officers

Actions specified in the Institute's constitution and by-laws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the Spring of 1932 will be held between November 15 and December 15. All suggestions for the consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, not later than November 15.

The sections of the constitution and by-laws governing these matters are quoted below:

Constitution

28. There shall be constituted each year a national nominating committee consisting of one representative of each geographical district, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical districts; all to be selected when and as provided in the by-laws; the national secretary of the Institute shall be the secretary of the national nominating committee, without voting power.

29. The executive committee of each geographical district shall act as a nominating committee of the candidate for election as vice-president of that district, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The national nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The national nominating committee shall name on or before December 15 of each year, one or more candidates for president, national treasurer and the proper number of directors and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical districts, if received by the national nominating committee when and as provided in the by-laws; otherwise the national nominating committee shall nominate one or more candidates for vice-president(s) from the district(s) concerned.

By-laws

SEC. 22. During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district that by November 1 of that year the executive committee of each district must select a member of that district to serve as a member of the national nominating committee and shall, by November 1, notify the secretary of the national nominating committee of the name of the member selected.

During September of each year, the secretary of the national moninating committee shall notify the chairman of the executive committee of each geographical district in which there is or will be during the year a vacancy in the office of vice-president, that by November 15 of that year a nomination for a vice-president from that district, made by the district executive committee, must be in the hands of the secretary of the national nominating committee.

Between October 1 and November 15 of each year, the board of directors shall choose five of its members to serve on the national nominating committee and shall notify the secretary of that committee of the names so selected, and shall also notify the five members selected.

The secretary of the national nominating committee shall give the fifteen members so selected not less than ten days' notice of the first meeting of the committee, which shall be held not later than December 15. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the national nominating committee must be received by the secretary of the committee by November 15. The nominations as made by the national nominating committee shall be published in the January issue of ELECTRICAL ENGINEERING, or otherwise mailed to the Institute membership during the month of January.

Signed F. L. HUTCHINSON,
National Secretary

October 1, 1931

H. L. Doherty Finances Unemployment Research.—Press reports of September 9, 1931, recorded the statement that Henry L. Doherty (A'98-F'13) widely known public utility operator has made available to the American Society of Mechanical Engineers a fund of $500,000 to provide for a study of the present industrial situation and to work out ways of remedying it.

Annual Safety Congress to be Most Extensive

The twentieth annual safety congress and exposition under the supervision of the National Safety Council is to be held in Chicago, October 12-16, 1931. An impressive list of 130 sessions with more than 300 speakers has been assembled for this conference which is to cover all the various organized fields of safety work. The public utilities section is an important part and represents about 400 organizations with more than 900,000 employees. The meetings of this section are to be held on October 13, 14, and 15. Another important group is the electric railway section which holds meetings on the same dates.

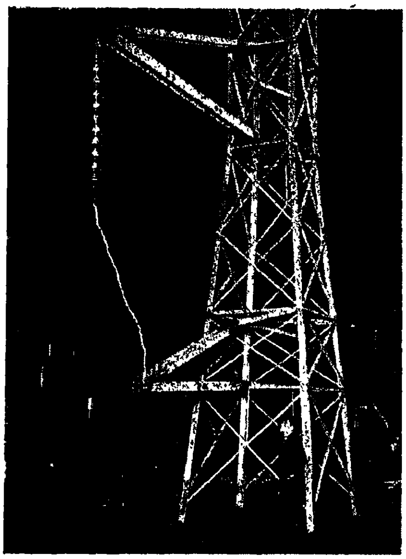
In addition to the sessions for specific industries there will be a number of special industrial sessions. Among these are sessions on industrial health and industrial psychology. One of the features of the congress will be the annual safety exposition in the large exhibition hall of the Stevens Hotel, where more than 100 exhibitors will display a panorama of standard safety equipment and the latest developments in safety appliances. This will be the most extensive and fully rounded safety congress ever held. It is significant that during these times of economy industrial safety activities have not slackened.

Executives to Visit Research Laboratories

A distinctive tour for industrial executives and bankers to important research laboratories has been arranged for October 5 to 15, 1931, under the auspices of the National Research Council. The purpose of the tour is to demonstrate the importance, value, and varied applications of research in industry, and by personal observation to study the operation and compare the different types of successful laboratories. The trip is similar to one made last year by a party of 100 selected industrial executives and bankers, and from which a number of very important by-products resulted.

The group will leave New York October 5 on a steamer for Boston; then continuing by train will visit research laboratories in the eastern part of the country. Dinners and accommodations have been arranged to insure the success of the trip. The laboratories to be visited are those of the Massachusetts Institute of Technology, Dewey and Almy Company, Arthur D. Little, Inc., Thompson and Lichtner Company, and the United Drug Company, all in Boston; the Eastman Kodak Company in Rochester; the Ford Motor Company and proving grounds at Detroit; Nela Park at Cleveland; Goodyear Tire and Rubber Company, and the Zeppelin Plant at Akron; the Basic Science Research Laboratories and Tanners Council at the University of Cincinnati, both in Cincinnati; Battelle Memorial Institute at Columbus; and the Westinghouse Electric & Manufacturing Company at East Pittsburgh. The executives of these laboratories are offering their fullest cooperation toward the success of the tour.

Indoor Tower Tests



SETTING a precedent for indoor lightning investigations, according to reports, the full-size section of 132-kv. transmission tower shown in the accompanying illustration recently was set up in the Westinghouse laboratories where 3,000,000-volt surges are available from an artificial lightning generator. The set-up was made to study the behavior of a wooden crossarm construction specified by the Union Electric Light & Power Company (St. Louis) for a new transmission line from its Osage plant to Rivermines station. During the test, Stone and Webster engineers found that it took 1,800 kv. to flashover the string of insulators when hung from the wooden crossarm, as compared to 1,100 kv. to flashover the same string with the usual steel supports. The man standing in the picture to show comparative sizes departed from the vicinity before the flash shown occurred.

Illuminating Engineers to Hold "Silver Anniversary"

Beginning October 12th, the Illuminating Engineering Society plans a four-day silver anniversary convention to be held at the William Penn Hotel, Pittsburgh, Pa. Reflecting in full measure the importance of the occasion, an outstanding technical program has been provided which has kept pace with the latest and newest developments in lighting practise and technique. A pre-convention meeting for central-station lighting service engineers will be held on October 12, and the Hon. James Francis Burke will give the address of welcome to the opening session on the morning of October 13. An architectural lighting session will be held that afternoon, and on the following day there will be a session on aviation lighting and an evening meeting which will include the conferring of honorary membership upon Dr. Elihu Thompson (Charter Member F'13-HM'28, and past-president) and Prof. André E. Blondel (A'05-HM'12). Lighting service and lighting practise sessions will be held on the following two days. Novel entertainment will feature the annual banquet and dance in the main ballroom of the William Penn Hotel on Thursday evening. Ideal golfing facilities will be available at the St. Clair Country Club. Special consideration is being given to women guests by a Committee appointed for this purpose. A. W. Robertson, chairman of the Westinghouse Electric & Manufacturing Company is chairman of the general convention committee.

Electrical Congress to be Held in Paris

The fifth meeting of the International Electrical Congress is to be held July 1932 in Paris, where the first meeting of this congress was held in the year 1881. Subsequent meetings were held in Chicago (1893) Paris (1900) and St. Louis (1904).

The purpose of the 1932 congress is to review developments of the last few years in electrical theory and practise, and to enact such rules and formulate such standards as may be of advantage to future electrical progress.

An American committee on organization has been appointed to arrange for the participation of technical and industrial organizations in the United States, and for the preparation of papers; it will welcome inquiries from persons interested in obtaining further information. The names of those serving follow:

E. W. Rice, chairman, General Elec. Co., Schenectady, N. Y.

G. K. Burgess, Bureau of Standards, Washington, D. C.
James Burke, Burke Elec. Co., Erie, Pa.
L. W. Chubb, Westinghouse E. & M. Co., E. Pittsburgh, Pa.
W. D. Coolidge, General Elec. Co., Schenectady, N. Y.
E. C. Crittenden, Bureau of Standards, Washington, D. C.
W. A. Del Mar, Habirshaw Cable & Wire Corp., Yonkers, N. Y.
Gano Dunn, 43 Exchange Pl., New York, N. Y.
L. L. Elden, Edison Elec. Illum. Co., 39 Boylston St., Boston, Mass.
L. A. Ferguson, Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.
A. N. Goldsmith, Radio Corp. of America, 570 Lexington Ave., New York, N. Y.
C. E. Harte, The Connecticut Co., New Haven, Conn.
D. C. Jackson, Mass. Inst. of Tech., Cambridge, Mass.
F. B. Jewett, American Tel. & Tel. Co., 195 Broadway, New York.
A. E. Kennelly, Harvard Univ., Cambridge, Mass.
C. O. Mailloux, 111 Fifth Ave., New York, N. Y.
J. H. McGraw, 10th Ave. & 36th St., New York, N. Y.
R. A. Millikan, Calif. Inst. of Tech., Pasadena, Calif.
I. E. Moultrop, Edison Elec. Illum. Co., 39 Boylston St., Boston, Mass.
F. D. Newbury, Westinghouse E. & M. Co., East Pittsburgh, Pa.
H. S. Osborne, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.
Farley Osgood, 31 Nassau St., New York, N. Y.
F. W. Peek, Jr., General Elec. Co., Schenectady, N. Y.
Harold Pender, Univ. of Penna., Philadelphia, Pa.
M. I. Pupin, Columbia Univ., New York, N. Y.
L. T. Robinson, General Elec. Co., Schenectady, N. Y.
L. B. Stillwell, 11 West 42nd St., New York, N. Y.
N. W. Storer, Westinghouse E. & M. Co., E. Pittsburgh, Pa.
S. W. Stratton, Mass. Inst. of Tech., Cambridge, Mass.
Philip Torchio, New York Edison Co., 124 E. 15th St., New York, N. Y.
W. R. Whitney, General Elec. Co., Schenectady, N. Y.

Welded Rail Committee Reports Further Progress

Progress Report Number Seven of the Committee on Welded Rail Joints recently was received at A. I. E. E. headquarters from the Institute's representative in that body, Prof. D. D. Ewing (F'20) of Purdue University, Lafayette, Indiana. This report has been filed for reference in the Engineering Societies Library, 29 West 39th Street, New York, N. Y. The committee is sponsored jointly by the American Bureau of Welding (welding research department of the American Welding Society and division of engineering of the National Research Council) the American Electric Railway Engineering Association, and the United States Bureau of Standards. Its membership comprises a total of about 60 individuals, including way engineers of several of the larger street railway companies, representatives of manufacturers of welded joints and welding equipment, welding experts, scientists, and testing experts.

About $24,000 was contributed originally for use of the committee by the American Electric Railway Association, interested manufacturers and a number of the larger street railways. The Railway Association is acting as treasurer for the fund, expenditures being made upon authorization of the executive committee appointed from the membership of the Committee on Welded Rail Joints. The principal objective of the committee is to improve each type of welded rail joint rather than simply to make comparative tests of the relative merits of these joints.

Previous reports (Reports No. 1 to 6 inclusive) indicate past progress made by the committee. The present report includes a study of the heat effects of thermit welds on the adjacent rail material; the effect of preheating and postheating welded specimens and rail joints; additional repeated impact tests of joints; and a study of butt and fishplate joints made with the atomic hydrogen process. The report includes also a study of stresses and distortions due to the heat of welding of low-carbon to high-carbon plates by Prof. T. R. Lawson of Rensselaer Polytechnic Institute, Troy, N. Y., and a discussion of this study by William Spraragen (M'26) of the National Research Council, New York.

Architects Study Simplified Practises

Typical of the service which the division of simplified practise of the National Bureau of Standards is equipped to supply are the simplified practise recommendations which they are now placing in the hands of each member of the American Institute of Architects. This institute has been active in supporting the simplification movement since the government first sponsored this in 1921.

The architect, although a strong individualist, realizes the benefits and savings inherent in simplification and at the same time knows that his individuality and originality of design are not impaired when simplified building materials are specified. It is not intended that simplification should mean standardization but that the industries will voluntarily limit varieties of stock items to those for which there is a constant demand.

Each member architect is being supplied with a complete list of simplified practise recommendations and is being informed of opportunities to obtain complimentary copies of any of the recommendations listed. Similar service for other industries has proved very popular and effective. Edwin W. Ely, chief of the division of simplified practise, states that this same service will be extended upon request to other associations.

Non-Magnetic Watch.—A new nickel-steel alloy originated by Dr. C. E. Guillaume, a winner of the Nobel Award in Physics, permits making a watch with hairspring and balance wheel which cannot be magnetized permanently. The conventional watch with regulation steel hairspring and the usual type of balance wheel becomes so erratic after exposure to magnetic fields up to 360 lines per sq. in. as to be rendered useless as a timekeeper. Extensive tests show that even in a field of 3,600 lines per sq. in. the hairspring and balance wheel of non-magnetically equipped watches were stopped only while actually within the magnetic field, resuming operation immediately upon removal therefrom. Ordinary watches under the same magnetic influence stopped "dead" and would not run again until they had been demagnetized.—*Telegraph and Telephone Age.*

Meeting of Committee on Electrical Insulation.—The fourth annual meeting and conference of the committee on electrical insulation of the division of engineering and industrial research of the National Research Council, will be held at Harvard University, Cambridge, Mass., November 13 and 14, 1931. There will be three technical sessions with papers on the physics and chemistry of dielectrics and on recent progress in engineering research in the field of dielectrics as applied to the insulation of electric circuits. A dinner on Friday evening will be followed by a lecture dealing with recent advances in dielectric theory. Dr. J. B. Whitehead of Johns Hopkins University is chairman of the committee.

South American Congress of Electrical Engineers.—The first congress of electrical engineers in South America is to be held at Buenos Aires from July 4 to 11, 1932, under the auspices of the Asociación Argentina de Electrotécnicos.

School of Welded Building Design.—The opening of a school of welding design at Schenectady, N. Y., has been announced by the General Electric Company. Its purpose is to teach engineers, architects, and draftsmen, both in and out of its employ, the methods of designing welded buildings. The course requires approximately four weeks for completion, and can be adjusted to suit the needs of each individual. There is no charge for instruction, the only requirement being that the applicant be an engineer or have some training in structural design or experience in the design of riveted structures. The differences between the application of welding and riveting to steel frames will be taught. The subject will be approached from a scientific point of view based on studies and tests made by this company over a period of years.

Letters to the Editor

Has Man Benefited by Engineering Progress?

To the Editor:

Permit me to express my complete sympathy with the statements made by Mr. Dreher in his letter published in the September issue (of Electrical Engineering, p. 766) commenting on Doctor Mees's article, "Has Man Benefited by Engineering Progress?" (Electrical Engineering, Aug. 1931, p. 642).

It is well that engineers begin to appraise the advantages of rapid industrial progress as against the importance of the social, intellectual, and spiritual advancement of the human race. It seems that with the growth of mechanical appliances, the necessity for thought has almost disappeared. People go through life controlled by custom, prejudice, and superstition, working for their sustenance at some routine job that requires an infinitesimal amount of brain work and employing the balance of their time in some amusement or recreation that requires still less of intellectual effort.

However, I do not quite agree with Mr. Dreher in his statement that "For all this, engineers are as much to blame as educators, priests, and magistrates." Perhaps the guilt of the educators and magistrates may be comparable to that of the engineers, but surely the greatest blame rests on the priests and other religious leaders who are supposed to lead the way for the social and spiritual advancement of the human race. As Mr. Dreher says, "The inability of men to cast off superstition . . . is fraught with the gravest danger." Probably this inability is due more than anything else to the great power of our present religious leadership, a leadership which is founded entirely on ancient superstitions, to mold public opinion.

Apparently there is among engineers, as among most people, a great fear of antagonizing existing religions, as they are preached by their leaders, and of finding themselves ostracized if they express opinions that seem to run counter to those of the masses, of that "stupid and sadistic herd," to use Mr. Dreher's words. Is it not time for engineers, who are trained from their early youth to learn the truth and to have an open mind, to begin to be frank and outspoken in their valuation of the leaders in other fields?

Only by freeing the human soul and mind from these shackles of prejudice and superstition can we expect the improvement in the social and spiritual life of humanity without which our great mechanical progress is valueless.

It is held quite generally that human nature does not change; I am enough of an optimist to believe that some day our mechanical progress will be considered of less importance than our social progress, and that we shall have leaders in ethics, biology, sociology, psychology, psychiatry, etc., who will convince us that human nature can change for the better; who will show us the way to assist consciously in making this upward progress more rapid. This will be the time when these leaders will be respected and followed to a greater extent than are our modern priests.

There is no reason for not confessing faith in a theory of evolution which has for its goal an ideal human being, possessing within himself, besides the intellectual power that scientific and mechanical progress indicates, a human or spiritual power which will make him realize that only as he can help to improve or enlarge the human values of those with whom he comes in contact can he himself become of greater worth as a member of the human race.

Yours truly,

G. LOBO (A'01, F'12)
(Pres. & Treas., Kelvin Engineering Co., Inc., New York, N. Y.)

Concerning Voice Training

To the Editor:

I wish to offer comment upon some of the statements appearing in "Voice Training on a Scientific Basis," published in the September, 1931, Electrical Engineering:

In order that the experience which may qualify me in making such comment may be known, permit me to say that my hobby is vocal music. Among the various instructors with whom I have studied, I might mention Dan Beddoe, nationally known concert and oratorio tenor, now with the Conservatory of Music of Cincinnati; and Italo Picchi, opera singer, formerly with the Metropolitan Opera Company of New York, now with the College of Music of Cincinnati.

Passing over the first and second paragraphs, which are introductory, the third paragraph I may say agrees precisely with my conceptions based on experience.

The fourth paragraph I also endorse with emphasis. It holds encouragement for the beginner—although some qualification of the statements may be made:

(1) It may be true that in certain cases physiological defects may be present; *e. g.*, a tonsillectomy not carefully done as to restriction in the area of cutting may impair a voice through interference with proper muscular action.

(2) A voice may be inherently not pleasing. I say this with hesitation, for although there is wide variation in individual timber or quality, so much depends upon the mental and emotional characteristics.

(3) Physical vitality is of considerable importance. (While a beautiful rendition of the work of "Violetta" in La Traviata might be made by some one who is "perpetually tired," a robust constitution would be an asset for the singing of the toreador song from Carmen—with encores. Probably it is simply a question of the energy required, both for the tone characteristics and demand upon endurance over a period of time. In other words, the quality of robustness is desirable in a singer; at least for certain work. Average health and vitality, however, are in general adequate, even for professional singing.)

My particular attention, however, has been arrested by the fifth paragraph. I should say definitely that the "lower register" covers the entire range of correct singing. The "register" or manner of tone formation should be uniform throughout the range used, the only difference in tones at different pitch being the naturally increasing pressure of breath as the scale is ascended. (Through exercise of control, lower tones may be sung "forte" and upper tones "piano"—but for a well-developed tone of consistent timber, the natural action will be as first stated.)

The singer's range is about two octaves (instead of three) for a well-developed voice. . . The falsetto or upper register tone is rarely used, and generally is untrained. It is a head tone, usually flat and unpleasing. We say it lacks resonance, but this may be due to inability to produce much vibrato on account of the different use of muscles and resonating cavities. A singer also is usually unable to make much of a crescendo on a falsetto note. Yodelling is the repeated transfer from natural to falsetto tone and the reverse. The falsetto is used by singers of repute occasionally for a pianissimo concluding note in a song, above the singer's natural range.

From a scientific standpoint, I should not take exception to any of the statements in the article except "The registers should be isolated and trained separately; only when fully developed should they be coordinated." From the practical point of view of the singer the value of this opinion is questionable.

I have the opinion that tremolo, or pitch variation, is a fault in singing technique. The author did not clearly define "tremolo;" and the statement that "The vibrato is the means for moving the voice correctly from tone to tone" does not seem to be consistent with his definition of vibrato nor my experience.

Much further scientific work might be done on the human voice, which might include:

(1) The relative contribution as resonators of the various head and throat cavities, and variation in relative volume of sound from nose, mouth, and external surfaces of head and neck.

(2) The possibility of beat notes between resonating cavities resulting in some vibrato without variation of muscular tension, as described in the article.

(3) A study of the transition in tone quality from an "open" to a "covered" tone. Mediocre singers habitually use a tone of one particular timber; the real artist varies the tone quality as well as the intensity and vibrato to suit the emotional interpretation.

(4) A common fault in singers is the incorrect tension of throat and soft, palate muscles. For the individual learning to sing, intelligent tutelage probably will be of more value than a scientific exposition of this subject.

(5) The reduction in range caused by fatigue—particularly the loss of lower notes.

Very truly yours,

CHARLES T. BUTTON (A'29)
(Sales Engineer, Holtzer-Cabot Electric Co., Cincinnati, Ohio)

The Engineer In Civic Affairs

To the Editor:

I was greatly interested in reading the article entitled "The Engineer in Civic Affairs," by J. Allen Johnson in the September issue of ELECTRICAL ENGINEERING (p. 727). The thought occurred to me that I could perhaps add my small bit to the question of solving this problem, due to the fact that I have mixed my engineering work with some public service, having served during my spare time as president of a village board of education for the past eight years, and as chairman of a village planning board for the last five years, during which time I was engaged also as engineer in the design of some of the largest electric power plants in the Metropolitan (New York) district.

Mr. Johnson divides the problem into two questions: (1) how to establish a high professional standing of engineers, and (2) how to establish a high standing of the engineering profession in public affairs.

In answer to question number one I should reply as follows:

It would seem that the rapid strides in engineering achievements during the past generation could not have been possible without the faith of the investing public in providing the necessary financial backing to carry out the ideas advanced by engineers, and the dependence of the public in general upon the skill of the engineer in looking out for public comfort and safety as exemplified in the immediate acceptance and use by the public of new developments as rapidly as they appear.

I should answer question number two as follows:

The question of establishing a high standing for the engineering profession in public affairs rests entirely upon the shoulders of the engineer. If the engineer who may be recognized as an outstanding figure in his profession will refrain from passing judgment on public problems until he has studied and analyzed them in the same manner in which he would attack an engineering problem, and then be prepared to back up his judgment with sound reasoning, the public soon would learn to respect such decisions and thereby bring credit to the profession. The engineer, however, in common with men in other walks of life, likes to have his vanity tickled by being asked questions on public affairs with which he is only remotely familiar, and feels that he must live up to his reputation by answering impromptu. He thereby falls into the trap of making statements, based on snap judgment, which appear ludicrous when broadcast in cold newspaper type.

Only when engineers come to realize that every time a more or less prominent member of their profession passes snap judgment on some outstanding public problem which cannot be solved off-hand, even by persons who have made a long study of such conditions, he thereby brings discredit to the entire profession in the minds of the public, then, and only then, will the necessary steps be taken to correct such conditions so that the profession as a whole can be placed in the position of high standing which it deserves.

As it is desirable that the engineering profession establish a high standing in its opinions on public affairs, the problem of creating such a standing should be attacked at the root. To obtain full and complete information on such problems it is necessary that individual engineers give up a portion of their time to gratuitous public service as suggested by Doctor Wickenden (and quoted by Mr. Johnson). It is only in this way that they can become thoroughly familiar with the thoughts and ideas of the people with regard to public affairs. With this information as a basis on which to work, local councils or committees on public affairs can be formed consisting of representatives of the various engineering organizations who are familiar with such problems through actual contact with the public.

Problems of local interest can be handled readily by these councils, but in order to cover larger problems, the work of the local committees should be coordinated by state-wide councils and, for national problems, through a national engineering council consisting of representatives of all the state councils.

Opinions on public affairs given by such an organization then would not represent the ideas of individual engineers on more or less unfamiliar subjects, but would represent the coordination of the thoughts and ideas of many highly trained minds conversant with the detailed aspects of each case. By means of a flexible organization of this type, consideration of public problems would be confined to the small group interested in local affairs or expanded to cover state or national issues as required to meet the particular case.

In conclusion I should add that in order to secure the confidence of the public in the opinions of the engineering profession in public affairs, there must be a realization among engineers that proficiency and success in their own profession does not of itself qualify them as authorities on public questions which are not of an engineering nature.

Very truly yours,
ROBERT BAKER (A'17)
(Chief Engineer, Thomas E.
Murray, Inc., New York, N. Y.)

A Formula for Happiness

To the Editor:

While the following is perhaps a rather tardy comment on Doctor Mees's refreshing query, "Has man benefited by engineering progress?" (ELECTRICAL ENGINEERING, Aug. 1931, p. 642) it is an immediate discussion on the discussion itself.

Doctor Mees's question was directed to engineers, but the answers so far published have exhibited philosophic elasticity rather than the conciseness one associates with engineering expression. Carl Dreher (ELECTRICAL ENGINEERING, Sept. 1931, p. 766) introduces Schiller into the controversy, and my equally good friend Professor Jansky (ELECTRICAL ENGINEERING, Sept. 1931, p. 766) like Torquemada, would substitute *welfare* for *happiness*. Happiness may be "incommeasurable," but at least it is tangible, intimate, and real, while welfare is often artificial, and arbitrary, with no consistent economic meaning. The Inquisition pinched, burned, racked, and quartered in the fair name of welfare. . . .

The problem is fundamentally hedonistic, and though it cannot be expressed numerically on, engineering principles are violated by the equation:

$$H = \sqrt{\frac{a}{b} - \frac{c}{k}}$$

where the symbols consistently represent emotional factors: H happiness, a the capacity to make the most of potential happiness, b potential happiness, c potential evil, and k the capacity of society to resist evil. History and psychology seem to indicate that over the historical period this last factor has remained constant.

Potential happiness b incontrovertibly has been increased by engineering progress (in the form of) movies, trips around the world, Rolls Royces, private yachts, airplanes, theatres—a thousand luxuries. But it is doubtful if our capacity to enjoy these things a has kept step with their potentiality. On the other hand, potential evil c certainly has received an increment with every major scientific development. Hence, with k a constant, it is probable that the Grecian Helot had not merely "as good a chance" but a better chance "for happiness than most modern factory workers."

It will be observed that if the factor c/k becomes lager than a/b (as necessarily occurs in the case of great economic distress, such as war, depression, strikes and wholesale banditry) happiness H becomes imaginary. And if philosophic considerations must enter into the discussion, inspection of the equation will indicate that the highest attainable happiness is expressed by unity, a mathematical interpretation compatible with Utopian bliss or Schopenhauer's positivity of evil.

Sincerely yours,
ZEH BOUCK (non member)
(Consulting Engineer
Flushing, L. I., New York)

Local Meetings

New York Power Group Opens Season With Talk on Cables

The Power Group of the New York Section will open the 1931-1932 meeting year on the evening of October 6 with a talk on "Power Cables—Development and Trends" by D. M. Simmons, chief consulting engineer of the General Cable Corporation.

Cable engineers have many choices regarding type of cable and insulating materials available for application to specific problems in the transmission and distribution of electricity, and Mr. Simmons will discuss their advantages and disadvantages. He will outline modern trends and show that present developments in the art, undreamed of a few years ago, make practical underground installations up to and including 220 kv. High lights of Mr. Simmons's talk will be emphasized with an interesting group of lantern slides.

In accordance with the established practise of the New York Section groups the meeting will be called promptly at 7:30 p. m. and will adjourn at 9:30 p. m. A cordial invitation is extended to all who wish to join in the discussion. The meeting will be held in Room 1, Fifth Floor, Engineering Societies Building, 33 West 39th Street, New York, N. Y.

New York Communication Group to Resume Activities October 27

The opening meeting of the New York Section's Communication Group will be held on Tuesday, October 27, 1931, at 7:30 p. m. in the auditorium at the Western Union Building, 60 Hudson Street, New York, N. Y. The noted physicist of the Bell Telephone Laboratories, Karl K. Darrow, will discuss "The Flow of Electricity in Various Media." His treatment of the subject will be popular rather than technical and will be of interest not only to men associated with any phase of the communication industry, but also to all members of the Section. Although the meeting will adjourn at 9:30 sharp, there will be ample opportunity for general discussion.

Chicago Section Power Group Organizes for 1931-1932

The Power Group of the Institute's Chicago Section was authorized in 1929 by the Section's executive committee, for the purpose of providing more meetings relating to the generation and distribution of power than were permitted by the limited schedule of formal Section meetings. Meetings of the group since have been held in the rooms of the Western Society of Engineers, with an average attendance of approximately 125; some of these were designated as joint meetings sponsored by that society and the Chicago Section.

L. W. Smith of Sargent & Lundy has been elected chairman of the Power Group for the season 1931-32 and the work will be carried on under the supervision of the executive committee the other members of which are:

F. L. Reinmann, Midland United Co., vice-chairman; A. J. Krupy, Commonwealth Edison Co.; N. O. Pearcy, Byllesby Engg. & Mgt. Corp.; H. T. Eddy, Public Service Co. of Northern Illinois; Gordon Cavanagh, North American Lt. & Pr. Co.

Montana Section Organized

Authority to organize a Montana Section of the Institute with the entire state as its territory was granted at the meeting of the board of directors held June 24, 1931. This Section was organized recently with Bozeman as its headquarters; officers elected are: *chairman*, Prof. J. A. Thaler, Montana State College; *secretary*, H. Dale Cline, Mountain States Telephone & Telegraph Company, Bozeman; *additional members of executive board*, W. A. Boyer, Butte; J. C. Dow, Great Falls; and Rollin Kennard, Great Falls.

Future Section Meetings

Lehigh Valley

October 16, 1931—First meeting of 1931-1932 season. RECENT DEVELOPMENTS IN TRANSFORMERS, by H. V. Putman, manager, transformer engineering department, Westinghouse Elec. & Mfg. Co. Meeting to be held at Altamont Hotel, Hazleton, Pa.

Toledo

October 16, 1931—HIGH TENSION D-C. TRANSMISSION, by H. R. Summerhayes, General Electric Company; ELECTRICAL SYSTEM OPERATION, by F. H. Dubs, Toledo Edison Company.

Past Section Meetings

Portland

SOME INSTITUTE PROBLEMS, by C. E. Skinner, president of the A. I. E. E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co, Also, motion pictures and lecture on Doctor Skinner's trip through the Orient. Dinner at the University Club preceded the meeting. August 18. Attendance 74.

Vancouver

SOME INSTITUTE PROBLEMS, by C. E. Skinner, president of the A. I. E. E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co. Doctor Skinner showed motion pictures which he had taken during his recent world tour. Dinner at the Georgia Hotel preceded the meeting. August 14. Attendance 33.

Personal

H. H. BARNES (F'13) of the General Electric Company, New York, N. Y., recently has been appointed a divisional chairman of the commerce and industry division of the Emergency Unemployment Relief Committee of New York City. Mr. Barnes will head the activities of the electrical industries in the division and will form a committee to conduct solicitations among individuals and corporations in the electrical field. The relief committee has been organized by business leaders to provide for New York's unemployed during the coming winter, and plans for coordinating the task of raising and distributing funds already have been announced.

L. M. CARGO (A'06) executive representative, Mountain States, Westinghouse Elec. & Mfg. Company, Denver, Colo., and recently elected president of the Electrical League of Colorado, was chosen a member of the League Council at the annual conference of electrical league managers held July 27-31, 1931 at Association Island, New York.

A. C. STREAMER (A'10) for some years assistant director of sales, Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa., has been appointed sales manager of the company's diversified products department in which is grouped all Westinghouse equipment not specifically alined with transportation, central station or industrial activities.

W. S. MOODY (A'06, F'12) consulting electrical engineer transformer department, Pittsfield, Mass. and for 43 years identified with transformer design and production for the General Electric Company, retired as of July 1, 1931, from active work. He however will retain in consulting capacity his connection with the company.

W. S. GIFFORD (A'16) president of the American Telephone & Telegraph Company, New York, N. Y., and director of President Hoover's unemployment relief organization, has been elected to membership on the finance committee of the United States Steel Corporation to succeed the late George F. Baker.

Henry G. Wood (A'23–M'28) assistant manager of the northeastern division of Westinghouse Elec. & Mfg. Company, New York, N. Y. recently changed to become electrical engineer in the general sales department of the Worthington Pump and Machinery Corporation, Harrison, N. J.

A. D. Stephanus (M'28) special representative of Westinghouse Electric International Company, Oslo, Norway, a short time since removed to the company's London office, 2 Norfolk Street, Strand, London W. C. 2, England.

William Shuler (A'15–M'24) until recently electrical engineer for the Columbia Engineering & Management Corporation, Cincinnati, Ohio, has accepted a position with the Dayton Power and Light Company of Dayton, Ohio.

H. E. Stafford (A'13–M'25) electrical engineer, Provincial Paper Mills, Ltd., Port Arthur, Ont., Canada, has changed his position to one with Moss Mines, Ltd., Tip Top Spur, Canadian National Railways, Ont., Canada.

Theodore Bodde (A'19) of the engineering department of the General Railway Signal Company, Rochester, N. Y., has received appointment to professorship at Northeastern University, Mudken, China.

W. P. Hammond (M'20) engineer of generating plants, Allied Engineers, Inc., Birmingham, Ala., has been appointed engineer for the Atlantic district of his company, to succeed L. N. Blagoveschensky.

M. A. Thomas (A'31) who previously has been located at the University of Texas, now is connected with the New Mexico College of A. & M. in the capacity of assistant professor of electrical engineering.

H. S. Evans (A'08) who was manager of the industrial department, Denver division of the Vacuum Oil Company, Incorporated, has removed to the New York headquarters of the company.

I. K. Dortort (A'29) until recently electrical engineer at Camden, N. J. for the Brown Boveri Company, has removed to Milwaukee, Wis., to join the Allis-Chalmers Mfg. Company.

Robert Landis (A'22) designing engineer at Brown Boveri Company's Camden (N. J.) plant now has joined the Allis-Chalmers Mfg. Company at Milwaukee, Wis.

H. Winograd (A'26) electrical engineer for the Brown Boveri Company, Camden, N. J., now is identified with the Allis-Chalmers Mfg. Company, Milwaukee, Wis.

Leo N. Blagoveschensky (A'25) who has been serving in the capacity of district engineer of Allied Engineers, Inc., Atlanta, Ga., has resigned from this position.

Obituary

Harry Phillips Davis (A'01, M'01) vice-president and director of the Westinghouse Electric and Manufacturing Company, chairman of the National Broadcasting Company, and one of the country's foremost engineers and executives, died at his home in Pittsburgh, Pa., September 10, 1931. He had been ill for several months, and at the time of his death was sixty-three years old. He was born at Somersworth, N. H., and was graduated with the degree of bachelor of science from Worcester Polytechnic Institute, from which in 1930 he received also the honorary degree of Doctor of Engineering. For more than 21 of the 40 years he was connected with the Westinghouse Company, he had charge of the company's engineering department; for 15 years, he directed its engineering and manufacturing operations. In 1911 he was elected a vice-president. Among his early achievements was his work in the electrification of the New York, New Haven and Hartford Railroad, the world's first single-phase railway electrification and a phenomenal engineering feat. His ability penetrated not only all phases of this electrification but many others that followed it. He was a man of indomitable energy, initiative, and vision, and his career was one of wide achievement. Nearly eighty electrical patents have been issued to him, and under his leadership many of the most important advances in the electrical art relating to meters, measuring instruments, circuit breakers, railway control, transmission, and radio, have been made. His foresight was perhaps most clearly demonstrated in the starting of the first broadcasting station; at a time when the public, and engineers as well, were looking upon radio quite definitely as a means of private or point-to-point communication, Mr. Davis envisioned it as a public service over a wide area and one to which everyone might listen. That was the birth of radio broadcasting, and by Mr. Davis it was looked upon as a public trust. With the success of the first station, November 2, 1920, he quickly placed others in service, thus establishing what may well be termed one of the greatest developments of the century. He was active in every phase of radio, and at the time of his death was known internationally as the "father of radio broadcasting."

Mr. Davis was director of more than a dozen corporations, among them the Westinghouse Electric International Company, Automatic Gear Shift Company, the Radio Corporation of America, R. C. A. Photophone, Inc., Radio-Keith-Orpheum Corporation, R. C. A.-Victor Company, Inc. He was also a vice-president of the Turtle Creek & Allegheny Railroad Company, and held membership in many engineering and scientific societies, the University Club of Pittsburgh, the Pittsburgh Athletic Association, and the Oakmont and Edgewood Country Clubs.

Edward James Condon (A'12, M'21) president of the Condon Engineering Company and General Power Company of Chicago, Ill., died suddenly August 25, 1931, of heart disease. He was 69 years old, having been born in Cambridge, Mass., and educated in the Boston public schools. He first became interested in engineering and utility work in 1893, and in association with several others accomplished a number of water and sewer contracts for the city of Chicago. In 1896 he directed the building of a reservoir on the southern slope of Pike's Peak for the city of Cripple Creek, Colo. The following year he returned to Chicago as a member of the firm of Cleary & Company, doing municipal work constructing water works, and gas and electric plants. As early as 1905 he became interested in several small electric plants, rebuilding some of them into an interconnected system in northeastern Indiana and southern Michigan. In 1924 these latter properties were bought by the Midland Utilities Company. Concurrent with his ownership and management of the Condon Engineering Company, he became president, general manager, and part owner of the Minnesota Electric Light & Power Company and the Eastern Montana Light & Power Company; still later he was elected to the vice-presidency and general management of the Inter-Mountain Railway, Light & Power Company, operating in sixty cities and towns in twelve states. In 1925 he became president of the General Power & Light Company, but in 1929 disposed of all of his utilities properties and devoting his entire time to the Condon Engineering Company. His friendly personality won for him a wide acquaintance, not only among the men of all ranks in professional and the utility fields, but in fraternal organizations as well. He was a past-president of the Indiana Electric Light Association. He was always active at technical conventions; and was a member of the Western Society of Engineers, the Art Institute (Chicago), and Knights of Columbus.

Edward Otto Zwietusch (A'22) general manager of C. Lorenz A. G., was killed in an automobile accident August 8, 1931. To German industry his death represents the loss of an exceptional organizer. An American by birth (Milwaukee), January 20, 1866) he attended the University of Wisconsin at Madison. In 1886 he entered the employ of the Western Electric Company, and there received a practical knowledge of telephony, then in its infancy. This knowledge he utilized by going to Berlin in 1888 and founding the Telephon-Apparat-Fabrik. In untiring effort, he invented many new methods of telephony which were immediately adopted by the Reichspost. Charmed with the country of his ancesters, Mr. Zwietusch in 1904 became a German citizen, until 1921 conducting his business in Salzufer; then he became the representative of the Western Electric Company with the International Standard Electric Corporation, a position which he held until 1926. In January 1927 he was appointed General Director of the Vereinigten Telephon und Telegraphenfabrik, A. G. Czeija, Nissk & Company, Vienna. At the completion of this work early in 1930 he undertook the management of the Telephonfabrik Berliner A. G. in Berlin-Steglitz, remaining until accepting his recent position. Mr. Zwietusch was a man of few words, but he studied every problem thoroughly not only from a theoretical point of view, but a practical business angle as well. He was a man much beloved by his co-workers and esteemed by all with whom he had business dealings.

Donald Fairfax Whiting (A'18, F'30) since January 1930 technical director and chief engineer of the Fox Hearst Corporation of New York City was killed in an accident on September 8, 1931. He was born in Lowell, Mass., April 13, 1891, and graduated from Worcester Polytechnic Institute in 1915, receiving his E. E. degree in 1922. He was licensed as an electrical engineer by the University of the State of New York in 1927. In 1916 he entered the special research department of the Western Electric company, and in 1925 was made supervisor of the apparatus development department of the Bell Telephone Laboratories. Two years later he became staff engineer in charge of testing and research for the Fox Hearst Corporation and in 1929 was promoted to direction of the work. In each of these affiliations, Mr. Whiting evidenced rare inventive genius. He was a member of the Institute of Radio Engineers and of the Society of Motion Picture Engineers; and a fellow of the Radio Club of America and of the American Association for the Advancement of Science. At the time of his death he was still active on the following committees: membership, Radio Club of America; papers, Radio Club of America; projection, Society of Motion Picture Engineers; and committee on standardization of the Institute of Radio Engineers.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Balaguer, Manuel M., c/o International Tel. & Tel. Co., 67 Broad St., New York, N. Y.

Bunce, Lewis I., Rocky Hill, Conn.

Clark, Bernard, 79 Jenness St., East Springfield, Mass.

Cole, Will G., Box 222, Westwood, Calif.

Farnlof, Charles G. T., 1318 Laketon Road, Wilkinsburg, Pa.

McLean, James S., 190 Old Army Road, Scarsdale, N. Y.

Melson, Sydney W., Yeatton Woolwich Road, Abbey Wood, London, S. E. 2, England.

Mountain, C. E., Burma Elec. Supply Co., Mandalay, Burma, India.

Parr, J. C., 245-71st Street, Brooklyn, N. Y.

Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.

Prudham, W. M., 100 Biddle St., Wilkinsburg, Pa.

Schrock, John E., 3720 Main St., Lawrence Park, Erie, Pa.

Stempfle, Frederick, 8126 E. Vernor Highway, Detroit, Mich.

Tate, William, Apartado No. 41, Publa, Mexico.

Voronovsky, T. G., 1162 Waverly Place, Schenectady, N. Y.

Test Code for Transformers

In the early part of 1929 a proposition was placed before the standards committee of the Institute, looking to the development of test codes for electrical machinery and apparatus. After a careful survey to obtain the reactions of key men in the manufacturing and electric power fields, the committee decided to proceed, covering for the time only the development of codes for the more important types of apparatus, such as generators, motors and transformers. This procedure was approved by the board of directors in May 1929. The standards committee then asked the electrical machinery committee to undertake the work, and at the meeting of July 23, 1931, the first report from the electrical machinery committee covering the "Test Code for Transformers" was received.

In order that the electrical industry might become fully cognizant of the work undertaken and at the same time be given a clear picture of just what it was contemplated to include in such test codes, the standards committee recommended to the board of directors that the "Test Code for Transformers" be made available to industry as a pamphlet published under the auspices of the electrical machinery committee. This suggestion was approved at the directors' August meeting, and the work of publication is now under way. Notice of the availability of the pamphlet will appear in a later issue of Electrical Engineering.

Engineering Foundation

Bequest of Edwin H. McHenry

United Engineering Trustees, Inc., has been made residuary legatee of the estate of Edwin H. McHenry of Ardmore, Pa. The estate is believed to amount to $225,000. Mr. McHenry died August 21, 1931. He was a member of the American Society of Civil Engineers. At one time he was receiver of the Northern Pacific Railway Company, and vice-president of the New York, New Haven & Hartford Railroad at the time when the electrification between New York and New Haven was undertaken; later he carried on a consulting practise. During his connection with the Northern Pacific Railway he was associated with the late Edward Dean Adams, through whose influence he made a small provision in his will for The Engineering Foundation. This he later changed to provide essentially that United Engineering Trustees, Inc. should receive the entire estate after the death of four beneficiaries who are to receive the income of the estate during their lives. Upon their decease, the entire principal of the trust estate is to be conveyed absolutely in fee to United Engineering Trustees, Inc. for The Engineering Foundation. Mr. McHenry makes this fund for research a memorial to his wife, Blanche H. McHenry, who died some years ago.

Standards

Several Projects Referred to New Committee

During July, approval of the new electrical standards committee was obtained from the eleven organizations of which it will be composed. This new committee supersedes the present electrical advisory committee of the American Standards Association, and will serve as a central agency in furthering the standardization work of the electrical industry. To this end all methods of procedure now recognized by A. S. A., as well as all powers for the formulation of standards, have been concentrated into one body, a new development initiated by the A. I. E. E. Resolutions transmitting it to A. S. A. were approved in January 1930 by the Institute's board of directors; steps are now under way for consolidating the work of the new committee with that of the U. S. national committee of the International Electrotechnical Commission. Detailed statement of this new development in electrical standardization was included in the August 1931 issue of the Bulletin of the A. S. A. which is obtainable from P. G. Agnew, secretary, A. S. A., 29 West 39th Street, New York, N. Y.

At the July 23rd meeting of the A. I. E. E. standards committee, action was taken recommending that several standards projects be referred to the new committee for disposition. These actions, subsequently confirmed by the board of directors, were:

1. Report No. 16, Railway Control Apparatus. This is a proposed revision of the present Institute and American standard on the same subject.

2. Standard N . 13, Transformers, Induction Regulators and Reactors. This is an Institute standard only, and reference was accompanied by suggested revisions.

3. Pamphlet No. 100, Recommendations for the Operation of Transformers.

4. Sixty-cycle Test Voltage for Transformers. This matter has been before the electrical machinery committee and there is a difference of opinion regarding its proper disposition.

5. Standard No. 12, Constant-Current Transformers, an A. I. E. E. standard since May 1930.

6. Report No. 18, Capacitors. Since May 1930 this has been a report on a proposed standard.

American Standards for Wood Poles Approved

For some time a sectional committee under the sponsorship of the telephone group of the American Standards Association and representing 23 organizations including the A. I. E. E., has been at work on the development of standards for wood poles. Already eight such standards have received the approval of the A. S. A., each standard covering ten classes of poles. These standards are available in four pamphlets dealing respectively with dimensions and specifications of (1) northern white cedar poles, (2) western red cedar poles, (3) chestnut poles, and (4) southern pine poles. These pamphlets are available at 20 cents per copy from the American Standards Association, 29 West 39th Street, New York, N. Y.

Relay Standards Report Available

A pamphlet, "Report on Standards for Relays" (A. I. E. E. standards report No. 23) is now available for suggestion and criticism. This report was prepared by a subcommittee of the A. I. E. E. standards committee under the chairmanship of George Sutherland of the New York & Queens Electric Light and Power Company; copies may be obtained free of charge from H. E. Farrer, secretary, Standards Committee, A. I. E. E., 33 West 39th Street, New York, N. Y.

The report deals with relays and relaying devices for the protection and control of apparatus and circuits for the generation, transmission, conversion, distribution and utilization of electric power. It does not include telephone, telegraph, traffic signal relays, or similar devices. The subjects covered are: service conditions, definitions, ratings, heating, limitations other than heating, dielectric tests.

New Standard Regulations for Signaling Systems

On recommendation of the National Fire Protection Association's committee on signaling systems, the regulations on protective signaling systems have been revised and divided into two separate pamphlets. The new regulations became effective September 15, 1931, displacing the former regulations on protective signaling systems, edition of 1929. The new pamphlets cover regulations for the installation, maintenance, and use of "Proprietary Auxiliary and Local Systems for Watchman, Fire Alarm, and Supervisory Service," and "Central Station Protective Signaling Systems for Watchman, Fire Alarm, and Supervisory Service." For further information and copies of pamphlets, address National Board of Fire Underwriters, 85 John Street, New York, N. Y.

Safety Code for Coal Mine Transportation

A safety code covering all phases of coal mine transportation recently has been approved by the American Standards Association as recommended American practise. The code deals with transportation on level and inclined tracks both underground and in mine yards; also haulage by motors, animals, or men. Complete systems of signals and safety rules are included. This work carried on under the sponsorship of the American Mining Congress has been in progress since 1924. Orders for the code may be placed with the American Standards Association, 29 West 39th Street, New York, N. Y.

New National Safety Code for Elevators

A new national safety code for elevators, dumbwaiters and escalators, recently has been approved by the American Standards Association. Developed under the sponsorship of the American Society of Mechanical Engineers, the American Institute of Architects and the U. S. Bureau of Standards, the revised code represents the result of nearly four years of research. For the first time, the code permits the operation of more than one elevator in a single shaft and also, provides for two-story cars serving two floors simultaneously. All communications relative to the code should be addressed to the American Standards Association, 29 West 39th Street, New York, N. Y.

Employment Notes

Of the Engineering Societies Employment Service

Position Available

SALES ENGINEER, 21 or 22, unmarried, to act as office engineer and secretary with manufacturers' agents sales office selling transmission and high-tension equipment for the New England States. Apply by letter giving complete information as to past experience, references and salary expected. Location, Boston. W-3080.

Men Available

TECHNICAL GRADUATE, 21, B. S. in E. E., 1931. Interested primarily in position offering stability, opportunity. Licensed broadcast class radio operator; two years' experience, operation and maintenance at 5-kw. station and general radio communication work. Prefers radio, telephone communication fields with work in laboratory, engineering department. Location, immaterial. Available immediately. C-9725.

ELECTRICAL ENGINEER, technical graduate, G. E. Test. Over 18 years' experience, including electrical manufacture; railway construction, valuation and maintenance; power line construction and steam railroad electrification. Desires position with company doing consultation and construction engineering or with operating company. B-7456.

GRADUATE ENGINEER, 22, single, B. S. in E. E., 1931. Two years' experience with public utilities in distribution and grounding work. Location, immaterial. C-9739.

ELECTRICAL-CIVIL ENGINEER, 27, married, university graduate. Desires position anywhere with public utility or contractor. Three years as sales and service engineer for electrical machinery manufacturer, specializing in synchronous equipment. One year as electrician on station construction. Two years varied civil engineering, including compressed air and rock-tunnel construction. C-4885.

ELECTRICAL AND CHEMICAL ENGINEER, 43, A. B. and B. S., executive experience in manufacturing and research; also public relations. Very successful in combating adverse publicity. Considerable experience in study of toxic gases. Available immediately. B-200.

COLLEGE GRADUATE, 23, single, B. S. in E. E., 1931. Desires work. Best of references. C-9747.

GRADUATE ELECTRICAL ENGINEER, 22, single, Lehigh University, 1930. Nine months' experience in the plant department of the American Telephone and Telegraph Company. Desires position with manufacturing concern or public utility. References furnished on request. Location, immaterial. C-9748.

PATENT ATTORNEY, 37, mechanical electrical engineer, independent reliable worker, broad, domestic, foreign experience acquired in research, industrial teaching, responsible engineering positions, five years with corporation patent department, now almost three years with large patent law firm, versed in foreign languages, growing clientele, desires connection with firm, attorney seeking competent intelligent cooperation. References available. C-9762.

RELAY AND CONTROL ENGINEER, 30, graduate McGill, location, Canada. Experienced planning protective circuits, automatic and supervisory controls. Familiar with equipment of generating stations, use of laboratory facilities and field engineering methods. Experienced on communication, amplifiers, photoelectric cells and maintenance of highest standards in associated circuits. Proven ability in personal contact. C-4668.

DESIGN ENGINEER, 27, technical graduate, 7 years' experience. Desires position with manufacturing firm. Experience covers: power station and substation design, production design of radio accessories, machine and tool, cemented tungsten-carbide development, power and conveyor equipment of nitrate plant. Good theoretical and practical background. Location, East. Available at once. C-4382.

GRADUATE ELECTRICAL ENGINEER, 33, married, B. S. in E. E. Eight years' experience in engineering work. Supervising design and construction of plant distribution, economic studies and cost estimating, public utility. Also sales engineering and contact work for manufacturing concern. Desires position with manufacturer, industrial concern or public utility. Location, United States. B-5858.

ELECTRICAL DESIGNER, 38, married. Fourteen years' public utility experience, five different corporations, power plant, switching station, substation, both indoor and outdoor. Desires connection with public utility or industrial organization. Available now. Location preferred, East. C-8490.

ELECTRICAL ENGINEER, graduate Georgia Tech., 1930, cooperative plan. Westinghouse lighting courses. Cooperative work, alternate months, five years in substation maintenance and office engineering. Rebuilding transformers, switches, lightning arresters, work with electric furnaces, rectifiers, meters, motors, etc. Checking and mapping distribution systems, work orders, drafting, etc. Excellent references. Perfect health. Location, immaterial. C-7847.

GRADUATE ELECTRICAL ENGINEER, 38, married. Sixteen years' experience in electrical engineering work. Central station design and specification. Light, power and signal systems for commercial and industrial buildings. Investigations, reports, design, layout, specifications, construction, inspection. Desires permanent position as electrical engineer with good opportunities for advancement. Connecticut or New York. B-1797.

ELECTRICAL ENGINEER, 31, married, no children, B. S. degree in 1923, working knowledge of Spanish. Over seven years' varied experience in planning, estimating, construction and operation of distribution and transmission systems. Location, immaterial. Available at once. C-9711.

ELECTRICAL ENGINEER, 32, married, Wisconsin graduate, construction, shop and seven years' power plant design experience. Available on short notice. C-9797.

EXECUTIVE ENGINEER, 40, graduate engineer, with ability to supervise and to create good-will and increase business through contacting and publicity. Would be valuable to electrical organization or organization serving the electrical industry. Has wide knowledge of industries and large acquaintance with engineers. C-9067.

ELECTRIC FURNACE PLANT MANAGER, mechanical engineer, abrasive and refractory experience. Engineering executive and designer. Expert in fluid flows and heat transfer problems. Analytical and inventive ability. Opportunity to secure experienced manager for small or branch plant. B-7972.

HYDROELECTRIC ENGINEER, 47, single. Degree Ph. B. in E. E., two years U. S. engineer. Ten years utility service as department manager, superintendent and chief engineer. Ten years Westinghouse industrial manager; five years electric dredging Alaska. Reports. Central America. Export manager Westinghouse two years. Available to go anywhere. B-6910.

ELECTRICAL ENGINEER, 44, married, B. S., E. E. Two years G. E. Test, eleven years motor applications; seven years with public utilities making variety of studies including transmission line, cable calculations, synchronous condenser applications, short circuit, load studies on d-c. calculating board, special research problems involving protective equipment. Location, United States. C-9811.

ENGINEERING DRAFTSMAN, 25, single, 2 years university training, 3 years' experience on power transmission lines, telephone work, and water resources. One year's experience as field aid. Available now. Will go anywhere. C-7118.

PLANNING ENGINEER, 31. Ten years' electrical-mechanical experience. Comprehensive knowledge coil, transformer, industrial meters and precision instrument design. Well versed in manufacturing methods, development, and cost reduction studies. Specialist in automatic control of processes, also general plant generation, transmission, distribution. Now employed. Accept position home or abroad. C-7258.

MECHANICAL-ELECTRICAL ENGINEER, 33, married. Graduate of recognized engineering school. Experienced in power generation. Five years teaching electrical and mechanical engineering. Heat power and specialty. High-voltage test. Extensive water gas research. Division engineer of water gas and coke ovens. Desires connection in teaching, public utility or industrial fields. Available immediately. C-9776.

ELECTRICAL ENGINEER, 33, married, B. S. in E. E. Ten years' experience as engineer with utility company. Familiar with design of lines and stations; accounting set-ups; executive duties and powers; modern business practise and now studying corporation law. Available at once. C-4734.

ELECTRICAL ENGINEER, 22, single, B. E. E. degree, 1931. Three years with Boston Edison Company, maintenance department on cooperative course. Temporarily employed last summer repairing Frigidaire cabinets for an ice cream company. Desires position offering some contact with engineering work. Location, anywhere. Available on two weeks' notice. C-9418.

GRADUATE ELECTRICAL ENGINEER, 27, single. Seven years' experience in supervising and laying out of electrical construction work in various industrial plants and buildings. Desires position as superintendent or electrical engineer with a contracting or industrial firm or municipality. Available at once. C-9553.

ELECTRICAL FOREMAN, 31, broad experience in power plant and factory construction, maintenance and operation. Exceptional ability in the erection and wiring of switchboards, power plant auxiliaries, oil circuit breakers and high-voltage substations. Available immediately. C-9783.

RECENT GRADUATE, age 21, single, citizen, good health, Protestant, B. E. E. degree, drafting and clerical experience, organization work. Would like to locate with a firm dealing with illumination of radio. Location, East. C-9756.

ELECTRICAL ENGINEERING GRADUATE, Columbia, 1931. Six-year man, single. Desires position with public utility or manufacturing concern. Studied especially power field, railroading and business administration. Experienced on automotive engines. Has acted as laboratory assistant in elementary E. E. courses. Languages: German and Spanish. Location, immaterial. Available immediately. C-9788.

RESEARCH PHYSICIST, 39, Ph. D., five years with Westinghouse on radio, television, sound recording and reproduction, four years bureau of standards and other government bureaus on optical design, heat engineering, also refrigeration experience, four years' teaching in prominent engineering schools, seeks responsible position in research or design. C-2588.

ELECTRICAL ENGINEER, 22, B. S.-E. E., 1930. Desires connection with public utility, electrical or radio manufacturing company. General Electric test experience. Six months' work with vacuum tubes. Experience with large motors. Location, immaterial. C-9806.

WIRING DIAGRAM SPECIALIST, 43, married, technical education, desires position with public utility. Understands cooperation necessary between office and field forces in connection with wirings. Familiar with powerhouse and substation layouts, conduit plans, bus structures, switchboards. Experienced in drafting and its application to field work. Location preferred East or South. C-8436.

ELECTRICAL ENGINEER, 36, single, E. E. degree. Desires position with public utility or engineering concern requiring executive ability and an analytical mind. Fourteen years' experience covering engineering, design and valuation of power plants, substations, transmission and distributions systems. Available immediately. Location, East. C-9570.

1931 GRADUATE of five-year cooperative school in electrical engineering. E. E. degree, age 23, single. Cooperative experience includes machine shop practise, telephone central office trouble shooting and experience with large municipal fire alarm system. Desires position with manufacturing concern or public utility. Willing to start at bottom. Location, Middlewest, preferred, but elsewhere satisfactory. C-9825.

ELECTRICAL ENGINEER, 29, single university graduate, Norwegian, now located in Canada. Five years' practical experience on drafting, designing, calculation, maintenance and testing for electrical machinery and equipment, substations, power transmissions, municipal and industrial distribution. Location, immaterial. Available on short notice. C-9822.

ELECTRICAL ENGINEER, 32, married, B. S. in E. E., graduate G. E. Test course, 3 years' practical experience light and power wiring, 3 years drafting, inspection, and installation of bank burglar alarm equipment. Desires position with electrical contracting company or bank burglar alarm company. B-8209.

TECHNICAL GRADUATE in mechanical and electrical engineering. Desires position as assistant sales engineer in electrical or mechanical equipment. Age 32, single, with ten years' experience in electrical and mechanical design and sales. Available at once. C-4510.

1931 GRADUATE ELECTRICAL ENGINEER, 29, 3 years' cooperative experience with large eastern public utility, single now, married when permanent position obtained. Desires position with utility, manufacturer or contractor. C-9834.

ELECTRICAL ENGINEER, 24, single, Iowa State College, 1931. Experience limited. Desires employment with public utility or manufacturing concern. Salary secondary to opportunity. Available at once. Location anywhere in the United States. C-9827.

ELECTRICAL ENGINEER, 30, married, B. S. in M. E. 1924, one year instructor of drawing and descriptive geometry in university. Six years design, construction of power plants, power substations, mining substations. Six months Westinghouse Test Course. Desires position as professor, instructor of design, electrical construction in university, technical school, Location, secondary. C-5734.

PRODUCTION OR EFFICIENCY ENGINEER, 26, E. E. graduate, 1929. Business administration. G. E. Test. Machine experience, turret lathes, boring mills, drills, millers, etc., automobile industry. Thoroughly familiar, tube rolling mill operations and processes. Distribution engineering, a-c. networks, electric utility. Private generating plants, studies and estimates on cost of retirement. Any location. C-9820.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with years' experience in industrial plant construction and maintenance; railway electrification; power plant design, estimating, and construction. Supervisory experience on construction and costs with contractor. Desires position with utility, manufacturer or contractor, where ability to handle labor and produce results is a prerequisite. C-4428.

GRADUATE ELECTRICAL ENGINEER, University of Wisconsin, 32, single. Three years Westinghouse Test. Seven years supervising power plant, substation transmisson line construction. Eight years engineer inspector, purchasing, expediting, resident engineer, and writing specifications. Excellent reference. Desires connection with holding company, utility, contractor or manufacturer. Available immediately. Location, immaterial. B-9661.

ELECTRICAL ENGINEERING ASSISTANT, 26, married, college graduate, four years' transmission and distribution experience with public utilities on design, estimates, survey and evaluation. Desires connection with public utility engineering department. New York city location preferred, but will consider any United States location. C-5511.

GRADUATE ELECTRICAL ENGINEER, 1930, single. One year's experience on test, design and development of small fractional and integral horsepower motors. Previous experience with public utilities. Now employed. Position must be permanent and promise a good future. Location a secondary factor. C-9590.

DESIGNING ENGINEER, 33, American, technical education, married, experience with industrial, mining and public utility companies, on power plants, steam and Diesel installations, including all auxiliaries, air conditioning and ventilating systems, automatic railway substations, outdoor substations, ability to requisition equipment, knowledge of steel, and concrete, can handle men. Location, immaterial. C-9849.

ELECTRICAL ENGINEER, 1930 graduate, 23, single. Fourteen months General Electric Test. Experience in automatic switchgear; circuit breakers; railroad motors, control, and locomotives; power rectifiers; synchronous converters, condensers, and motors; large motors, generators; transformers and variable speed a-c. machinery; calculating stability of transmission lines. Desires position in engineering field. Location, immaterial. C-9841.

ELECTRICAL ENGINEER, 22, single, B. S. E. E. 1931, from Pennsylvania State College, available on reasonable notice. One year's experience with silk-mill equipment, three months in transmission department of public utility, two semesters' motor tests in college. Desires position with utility, engineering or manufacturing company. Location, U. S., East preferred. C-9850.

MECHANICAL AND ELECTRICAL ENGINEER, research, development, reports, physical tests of materials, metallography, X-ray analysis. Languages: French and German. Available on short notice. Location immaterial. C-6094.

GRADUATE ELECTRICAL ENGINEER, 1929, 23, single; 15 months on G. E. Test Course. Desires position with utility or manufacturing company or with concern doing consulting or construction engineering. Available immediately. Location, New England preferred. C-8028.

ELECTRICAL ENGINEER, college graduate, age 23, married. Considerable experience in service and testing of fractional horsepower motors. Laboratory assistant and construction work while at college. Desires opening with advancement and opportunities. Available two weeks' notice. C-9084.

ENGINEER, 42, married; B. S. and E. E. Broad experience covering business, plant, sales management; executive engineering; research; drafting; patent investigations; organization and coordination of departments; assistant to busy executives; group engineering leadership; design and manufacture electrical and radio equipment. One employer sixteen years. Traveled extensively on business United States and abroad. C-9804.

INDUSTRIAL ELECTRICAL ENGINEERING GRADUATE, 1931, Pratt Institute, 23, single. Additional course taken in motor control. Four years' experience; power and lighting installation; servicing motors and control equipment. Some mechanical experience. Desires position with utility company; concern doing consulting or construction engineering or related work with manufacturing concern. C-9856.

DISTRIBUTION SUPERINTENDENT, 45, single. Graduate civil engineering. Two years transmission line surveying. Four years designing overhead lines, rural extensions, conversion from 2,300 to 4,000 volts. One year designing complete distribution systems in South America. One year superintendent operating company. Fluent Spanish, some French, German, Italian. C-2495.

ELECTRICAL ENGINEER, technical graduate, 31, married, desires position in electrical engineering field. Five years' experience in plant and substation construction, operation, maintenance and repairs; switchboard erection; motor and centrifugal pump installation and maintenance; inspection of electrical equipment. Location preferred, eastern United States. C-6273.

ELECTRICAL ENGINEER, graduate 1928, age 27, married. Has over two and one-half years' industrial testing experience, particularly in motor and control; also civil engineering and supervisory experience. Not afraid of responsibility. Desires a position with a future. Location immaterial. C-9568.

ELECTRICAL ENGINEER, age 32, married. Six years' experience with large manufacturer, on testing; design of a-c. machines, general and application engineering, and sales on power generation and transmission equipment. Three years' experience consulting and planning engineer for utilities. Desires connection with utility or manufacturer. Location immaterial. C-9814.

ELECTRICAL ENGINEER, 23, B. S. in E. E., University of New Hampshire, 1930. Fourteen months G. E. Test and general course. Test experience in transportation, motors and generators and vacuum tubes. Nine months summer work in main line electric railway shops. Interested in any engineering work. Available short notice. C-9859.

ELECTRICAL ENGINEER, technical graduate, American, age 29, married. Three years power test with G. E. and utility company. Three years research and development on electrical equipment. More interested in permanent connection with reliable concern than high starting salary. Eastern location preferred. Available immediately. C-1017.

GRADUATE ELECTRICAL ENGINEER, B. E. E. Degree 1930, age 24, single. Fourteen months' experience in the layout and estimation of underground network in a large city. Three months substation maintenance. Desires transmission line or distribution system work. Middlewest preferred. C-9860.

ELECTRICAL ENGINEER, 21, single; 1931 graduate with B. S. in E. E. Member of honorary fraternity in college and won scholarship three consecutive years. Summer experience with public utility. Interested in any electrical engineering field including vacuum tube work. Available at once. Location, New York preferred but not essential. C-9467.

PHYSICIST, 40, married; experienced in X-ray, radium and high frequency, desires position in electrical research. C-8604.

ELECTRICAL ENGINEER, graduate, 1929, cooperative school, American, Protestant, 31, married. Three years design, engineering, appraisal. Six years electrical construction, generating station and substation power company. Wishes position with public utility as junior engineer or in research laboratory. Will go anywhere, United States. Available now. Unemployed. C-9861.

GRADUATE ENGINEER, Stevens Institute of Technology, 1931, single, 22, available immediately. Desires position in any electrical line with opportunity for advancement. Location, immaterial. C-9473.

MECHANICAL AND ELECTRICAL ENGINEER, married; degrees here, and Doctor, Germany for research. Fifteen years connected and in charge purchasing, sales and export office handling materials every possible description in large amounts. Wide business experience. Linguist. Adaptable to any position outside those mentioned. C-7823.

ELECTRICAL ENGINEER, 26, single, 1928 graduate of recognized university with B. E. E. degree; four years' engineering experience; including 20 months on large electrified railroad, one year public utility test experience, one year communication and radio experience. Desires engineering position. Free to locate anywhere. C-9112.

GRADUATE ELECTRICAL ENGINEER, M. S. in E. E., 1931 from Massachusetts Institute of Technology majoring in communications.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
L. E. Griffith, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Desires position with electrical company or as instructor in electrical engineering, physics or mathematics. Summer experience with telephone company. Available immediately. Location immaterial. Age 23. C-9674.

1931 TECHNICAL GRADUATE, B. Sc. in E. E. from a midwestern University, desires permanent connection with chance for advancement. Age 26. Location immaterial. Available immediately. C-9717.

ELECTRICAL ENGINEER, 1930, single, 22, graduate Pratt Institute. Desires position in any electrical line with opportunity for advancement. Has had electrical and mechanical engineering and drafting experience. Location immaterial. Available immediately. C-8380.

ELECTRICAL ENGINEER, 1924 graduate, B. S. E. E., 29, married. Seven years' experience testing, inspecting, installing various electrical equipment. Writing reports. Assistant to manager power and light utility. Purchasing electrical supplies. Available immediately. Detailed information, references gladly furnished. Welcomes opportunity particularly in operating, maintenance department, public utility or manufacturing concern. C-4981.

SALES EXECUTIVE. Not afraid to work, not too old to acquire new ideas. Electrical training, Worcester Polytechnic Institute. Seven years directing engineering sales and sales through distributors. Capable of contacting industrial or electrical field with either an electrical or mechanical product. Industrious, with dependent, ready to go to work. C-5481.

ELECTRICAL ENGINEER, 1928 graduate. Three years' experience in large industrial plant on maintenance and operation of all kinds of motors, switchboards, electric heating, pyrometers, regulators and transformers, both theoretical and practical. Desires any electrical position. C-9845.

TECHNICAL GRADUATE, 38, married; desires position in engineering or operating department of power company. Has had 11½ years' experience with distribution engineer and operating and construction departments of public utility; 1½ years test; and 3 years shop experience. Location immaterial. B-9248.

ELECTRICAL DESIGN ENGINEER, 25 years' experience with public utilities, industrial companies, steam, hydroelectric power plants, H. T. indoor and outdoor substations, copper and nitrate mining plants, layouts, specifications, purchase of equipment, able to take charge, seeks position of responsibility. New York State professional engineer's license. B-7031.

1931 GRADUATE, North Carolina State College, B. S. in E. E., 25. Would take position of any type that offers advancement. Member of Tau Beta Pi and Phi Kappa Phi. Willing to go anywhere. C-9865.

Membership

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before October 31, 1931.

Bennett, D. S., Worcester Electric Light Co., Worcester, Mass.

Bibish, J. E., Libbey Owens Ford Glass Co., Toledo, Ohio

Burch, W., Carolina Power & Light Co., Raleigh, N. C.

Craton, F. H., General Electric Co., Erie, Pa.

Davies, L. S., Provincial Mental Hospital, Essondale, B. C., Canada

Dubielzig, R. C., 3361 N. 24th St., Milwaukee, Wis.

Ellis, C. R. (Member) Electric Bond & Share Co., New York, N. Y.

Goodenough, F. J., Amalgamated Electric Corp., Toronto, Canada

Gove, H. E., Union Electric Light & Power Co., St. Louis, Mo.

Harrington, N. F., R. W. Cramer & Co., New York, N. Y.

Hart, J. W., Electric Bond & Share Co., New York, N. Y.

Hogan, J. P. (Member) Parsons, Klapp, Brinckerhoff & Douglas, Enggs. & Managers, New York City, N. Y.

Ianantuono, Michael, 156 Sullivan St., New York, N. Y.

Jordan, R. L., University of Illinois, Urbana, Ill.

Karlsson, E. E., Associated Telephone Co., Ltd., Los Angeles, Calif.

Keller, E. A., Crocker-Wheeler Co., Ampere, N. J.

Kron, J., 144-30 35th Ave., Flushing, N. Y.

Laiho, J. M., 34 Remsen St., Brooklyn, N. Y.

Laughlin, C. W., American Tel. & Tel. Co., Kansas City, Mo.

Lober, C., Kansas City Power & Light Co., Kansas City, Mo.

Murphy, L. J., Westinghouse Elec. & Mfg. Co., New York, N. Y.

Nicolaisen, J. Z., Beauharnois Construction Co., Beauharnois, Que., Can.

Novotny, F. J., International Tel. & Tel. Co., New York, N. Y.

O'Beirne, F. H. C., Canadian Utilities, Ltd., Yorkton, Sask., Can.

Saxe, J., Electric Co. of Costa Rica, Cartago, Costa Rica, Central America

Speckmann, F. William, Jr., 312 Grove St., Newark, N. J.

Tamburello, G., 307 West 20th St., New York, N. Y.

Van Brunt, G. A. (Member) McGraw-Hill Publishing Co., New York, N. Y.

Voras, F. J., New York & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.

Wilson, I. H., General Electric Co., West Lynn, Mass.

Woodford, L. G. (Member) American Tel. & Tel. Co., New York, N. Y.

31 Domestic

Foreign

Dutta, S. K., Berlin Electric Supply Corp., Berlin, Germany

Ellis, D. W. V. (Member) Government of Northern Rhodesia, Ndola, No. Rhodesia, So. Africa

Kanga, D. P., College of Technology, Manchester, Eng.

Ratnam, V. S., Delhi Cloth Mills, Delhi, India

4 Foreign

October 1931

Order Form for Pamphlet Copies of A. I. E. E. Papers*

Papers presented prior to September 1931 and upon which articles in this issue are based

Number	Author	Title
☐ 31-14	G. M. Schrum and H. G. Weist, Jr.	Some Experiments with Arcs Between Metal Electrodes
☐ 31-29	W. J. McClain	Electrical Distribution Systems for Industrial Plants
☐ 31-43	M. A. Hyde, Jr.	Synchronous Motor with Phase-Connected Damper Winding for High-Torque Loads
☐ 31-49	A. W. Hull and H. D. Brown	Mercury-Arc Rectifier Research
☐ 30-50	W. R. King	Electron Tubes in Industry
☐ 31-62	D. W. McLenegan and A. G. Ferriss	Synchronous Motors—Design and Application to Meet Special Requirements
☐ 31-70	E. V. DeBlieux	Losses in Transformers for Use with Mercury Arc Rectifiers
☐ 31-98	P. B. Juhnke	Communication Facilities of a Metropolitan Power System
☐ 31-104	R. N. Conwell, G. M. Keenan, C. F. Craig, and E. C. Briggs	Communication Serivces of Electric Utilities—Underlying Considerations
☐ 31-111	E. S. Bundy	Communication in the Western Division of the Niagara Hudson System
☐ 31-113	C. A. Booker and M. E. Clark	Cooperative Study of Power System Communication
☐ 31-116	E. C. Stewart	Communication on the Arkansas-Louisiana-Mississippi Interconnected System
☐ 31-132	J. Slepian and L. R. Ludwig	Backfires in Mercury Arc Rectifiers
☐ 31M8	P. N. Winther	Electric Arc Welding in Building Construction
☐ 31M13	O. H. Frier	Telegraphic Pilot-Wire Relay System

*Members, Enrolled Students, and subscribers are entitled to one pamphlet copy of any paper in this list if requested within one year from above date. Thereafter charge of twenty-five cents per copy will obtain.

Name..

Address..

Please order papers by number. ***Address*** **Order Department A. I. E. E., 33 West 39th Street, New York, N. Y.**

New Books
In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during August are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following 'outlines, information for which is taken from the preface or text of the book in question.

BERECHNUNG VON DREHSTROM-KRAFTUBERTRAGUNGEN. By O. Burger. 2nd ed. Berlin, J. Springer, 1931. 183 pp., illus., diagrs., charts, tables, 8 x 6 in., cloth. 13.50 r. m.——A concise yet complete description of a practical method for the calculation of the electrical characteristics of three-phase transmission systems of any capacity. The method given is the outgrowth of many years of experience with the Siemens-Schuckert Works.

DIE BETRIEBSUNTERSUCHUNG WEGE UND FORMEN. By O. Bredt. Berlin, VDI Verlag, 1931. 56 pp., charts, tables, 12 x 8 in., paper, 12 r. m.——Dr. Bredt discusses the development of management-research in America and Europe and presents a detailed description of the methods used in five typical cases. These cases are then criticized in detail, and the efficacy of the methods used is discussed. The general principles and methods of procedure are then demonstrated by reference to an investigation by the National Board of Economics of Germany. The book shows the possibilities of management research and is a brief compendium of methods.

DIELECTRIC CONSTANT AND MOLECULAR STRUCTURE. American Chemical Society Monograph 55. By C. P. Smyth. N. Y., Chemical Catalog Co., 1931. 214 pp., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——The author has correlated and organized the known facts bearing upon the problems of electric moment, molecular structure and intermolecular action, and uses them in a critical examination of the theories and hypotheses in terms of which they are interpreted.

DRUCKWECHSEL UND STOSSE AN KOBLENMASCHINEN MIT SCHUBKURBELGETRIEBE. 1 v. Text and 1 v. Tables. By F. Kuba. Vienna, Julius Springer, 1931. 69 pp., diagrs., tables, 14 x 9 in., paper, 18 r. m.——A theoretical investigation of the phenomena accompanying reversals of pressure in reciprocating engines. The author develops a method of determining the relative velocity of the various phenomena, analyzes these phenomena into special components and points out the effect of changes in the conditions upon the relative magnitudes. The investigation aims to afford a sound basis for studying shocks in engine bearings, etc. A critical review of previous publications on the subject is included.

ECONOMICS FOR ENGINEERS. By E. L. Bowers and R. H. Rowntree. N. Y., McGraw-Hill Book Co., 1931. 490 pp., diagrs., charts, maps, tables, 9 x 6 in., cloth. $4.00.——This text-book on economics has been written to give engineering students a knowledge of economic principles and problems. The subject is presented very concisely, in order not to burden the curriculum unduly, and the engineering aspects of economic theory and business activity are emphasized. A practical presentation of the subject from an engineering point of view.

ENGINEERING PROBLEMS MANUAL. By F. C. Dana and E. H. Willmarth. 2nd edit. N. Y., McGraw-Hill Book Co., 1931. 252 pp., illus., diagrs., charts, tables, 8 x 5 in., $2.00.——This manual has been prepared primarily for use in the courses in engineering problems now given at some colleges to train the beginner in proper habits, effective methods and systematic workmanship, and to correlate his courses in physics and mathematics with engineering. It contains specifications for computation sheets, advice on habits of work and study, concise notes on fundamental principles and mathematics, three hundred practical problems and a collection of tables. The new edition has been revised and partly rewritten.

LE FACTEUR DE PUISSANCE, DES INSTALLATIONS ELECTRIQUES INDUSTRIELLES. By R Menjelou. Paris, Dunod, 1931. 239 pp., illus., diagrs., charts, tables, 10 x 6 in., cloth, 73 frs.——A systematic review of the power-factor problem. The effect of the power factor upon electric systems, the causes of a poor power factor and the methods by which it can be improved are discussed.

DAS FERNSPRECHWESEN III. SAMMLUNG GOSCHEN BD. 1043. By H. Schmidt. Berlin and Leipzig. Walter de Gruyter & Co., 1931. 139 pp., illus., diagrs., charts, 6 x 4 in., cloth, 1,80 r. m.——A brief elementary description of the principles of automatic telephony, describing the design and operation of the various types of apparatus in use.

FORSCHUNGSHEFT 346. WARMSPANNUNGEN IN GLEICHDRUCKWARMESPEICHERN. By E. Mayer. Berlin, VDI-Verlag, 1931. 23 pp., diagrs., charts, 12 x 9 in., paper, 5 r. m.——This research report deals with an experimental and theoretical investigation of the heat stresses in steam accumulators of the constant pressure type. The work was done at the Karlsruhe Technical University.

INHALTSVERZEICHNIS DER ZEITSCHRIFT DES VEREINES DEUTSCHER INGENIEURE, 1926-1930. Bd. 70-74, Berlin, VDI Verlag, 1931. 138 pp., 12 x 8 in., paper, 8 r. m.——This index, covering the last five volumes of the "Zeitschrift," contains over 3,500 entries to authors and subjects, and is an important guide to recent engineering developments, especially to the work of German engineers.

INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA, PHYSICS, CHEMISTRY AND TECHNOLOGY. INDEX v.1-7. By the National Research Council. N. Y., McGraw-Hill Book Co. 1930. 43 pp., 11 x 9 in., paper.——An index to the complete set, published in four languages, English, French, German and Italian.

MATERIALS OF CONSTRUCTION. By A. P. Mills. 4th ed., edited by H. W. Hayward. N. Y., John Wiley & Sons, 1931. 423 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——The aim of this work is to supply a general text-book upon the manufacture, properties and uses of the common engineering materials, for students of engineering. The book is to be supplemented by a laboratory course in the testing of materials. The new edition has been revised and enlarged.

POWER AND THE INTERNAL COMBUSTION ENGINE. By W. E. Dalby. N. Y., Longmans, Green & Co., 1931. 280 pp., diagrs., charts, tables, 9 x 6 in., cloth, $7.00.——Professor Dalby here treats of the common principles of the internal combustion engine. The first chapter is devoted to the physical and thermodynamical properties of a working agent formed from a gaseous charge by explosion. The second chapter considers in more detail fuels and the charges formed by mixing them with air, and the products of their combustion. The engine and its performance are the subject of chapter four, which is followed by a chapter on the performance diagram devised by the author. Succeeding chapters are devoted to the suction gas plant, the gasoline engine, and the effect of heat flow on design. The book contains much to interest the designer.

PRINCIPLES AND PRACTICE OF GEOPHYSICAL PROSPECTING, report of the Imperial Geophysical Experimental Survey. Cambridge (England) University Press; N. Y., Macmillan Co., 1931. 372 pp., illus., diagrs., charts, maps, tables, 11 x 9 in., cloth, $5.00.——This report records the results of eighteen months of work in Australia, undertaken to test the applicability of the principal geophysical methods under field conditions, for the purpose of determining their practical value and relative merits. Electrical, gravimetric, magnetic and seismic methods were used in country carrying sulphide and other ores, graphite, brown coal, saline waters, etc. The report is more in the nature of a manual of geophysical prospecting, illustrated by field results, than of a formal report. In part one the field investigations and elementary expositions of the different methods are given in readily understood form. Part two explains the field procedure in greater detail and discusses the design of apparatus, the interpretation of results and the underlying theory. Much new information upon electrical instruments is included.

SCIENCE AND RELIGION, a Symposium with a foreword by M. Pupin. N. Y., Charles Scribner's Sons, 1931. 175 pp., 8 x 5 in., cloth, $1.75.——In the fall of 1930 the British Broadcasting Corporation arranged a series of talks, in which eminent scientists, churchmen, and philosophers were asked to give their personal interpretation of the relation of science to religion and to determine to what degree the conclusions of modern science affect religious dogma and the fundamental tenets of Christian belief. These addresses now appear in print. with a oreword by Professor Pupin, and are, of unusual interest as a representation of the mature thought of distinguished leaders in the two fields. Among the twelve contributors are Sir J. Arthur Thomson, Julian Huxley, Sir Arthur Eddington, the Bishop of Birmingham, Dean Inge and Canon Streeter.

TELEVISION. By E. H. Felix. N. Y., McGraw-Hill Book Co., 1931. 272 pp., illus., diagrs., charts, 8 x 5 in., cloth, $2.50.——This book explains the basic processes involved in any television system and describes the methods of existing systems. The standards of performance requisite to commercial service are outlined, and the limitations of existing methods are pointed out. The book gives a good general survey, in not too technical language, of the present situation, the problems that television faces, and its probable future.

VECTOR REPRESENTATION FOR ELECTRICAL METERMEN. By D. T. Canfield. N. Y., McGraw-Hill Book Co., 1931. 180 pp., diagrs., charts, tables, 8 x 6 in., cloth, $2.00.——This book explains the vector representation of alternating voltages and currents in simple language, with very little use of mathematics. The theory of vectors and their manipulation are first described in a non-mathematical, non-technical way. This is followed by a more technical presentation of the subject, after which the use of vectors in the solution of polyphase problems and power-factor correction is shown by practical examples. While intended primarily for metermen, the book will be useful to any one seeking an elementary text.

2ND WORLD POWER CONFERENCE, Berlin, 1930. Transactions, Bd. 20, Index. Berlin, VDI-Verlag, 10 x 6 in., cloth, $85.00 per set.——This volume completes the Transactions of this conference, held in Berlin in June, 1930. The Transactions contain the papers presented, numbering over three hundred and fifty. These are in twenty volumes of handy size, each containing papers upon related subjects, which may be purchased singly. These are fully indexed by author and subject in this final volume. The index is tri-lingual—English, German, and French.

FRENCH-ENGLISH AND ENGLISH-FRENCH DICTIONARY OF COMMERCIAL AND FINANCIAL TERMS, PHRASES AND PRACTICE. By J. O. Kettridge. N. Y., E. P. Dutton & Co., 1931. 647 pp., 10 x 7 in., cloth, $7.50.——This work gives the translations of fifty thousand words, terms and phrases frequently used in commercial and financial writings, and illustrates their use by numerous examples and explanations. The book is clearly printed and of convenient size. It will fill a long felt want among translators, as it occupies a new field, and will do so very satisfactorily.

CREEP OF METALS. By H. J. Tapsell. London, Oxford University Press, 1931. 285 pp., illus., diagrs., charts, tables, 10 x 6 in., cloth, 30 s. (American Price $12.00).——A very complete presentation of the data available upon the creep of metals at high temperatures. The work of the various investigators has been correlated, in the light of the test methods used by them, with the aim of enabling the engineer to a satisfactory interpretation of present and future data, and the successful use of them.

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Selected Items From
Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Armatures

WINDINGS. Unbalanced Voltage in Armature Coils, R. M. Baker. *Elec. Jl.*, vol. 28, no. 5, May 1931, pp. 315-317, and 321, 12 figs. Set-up for studying circulating current conditions by means of oscillograph analysis of results.

Busbars

Current-carrying Capacity of Bare Cylindrical Conductors for Indoor and Outdoor Service, C. W. Frick. *Gen. Elec. Rev.*, vol. 34, no. 8, Aug. 1931, pp. 464-471, 8 figs. Carrying capacity tables for bare indoor conductors and at 100 per cent conductivity copper, horizontal position, 40 deg. cent. air temperature in large rooms without drafts and 60 cycles and for bare outdoor conductors of same material in partly sheltered locations; relative capacities for conductors of same diameter and cross-section made of metals having different values of conductivity; formulas for calculation of current *vs.* temperature rise; resistance data.

TESTING. Aluminum Busbars Resist Power Arcs, J. D. Porter. *Elec. World*, vol. 98, no. 3, July 18, 1931, pp. 104-105, 1 fig. Tests made by engineers of Westinghouse Electric & Manufacturing Co.'s high-power laboratory on behalf of Aluminum Co. of America, in order to determine effect of power arcs of long duration on tubular aluminum busbar under various currents and with several different weights and thicknesses of tubing.

Cables

DIELECTRIC LOSSES. The Significance of Dielectric Loss in High Voltage Cables, M. C. Timms. *Elec. Engr. Australia and New Zealand*, vol. 8, no. 3, June 15, 1931, pp. 95-100, 5 figs. Origin of dielectric loss; leakance; ionization loss; analysis of dielectric loss; effect of inherent dielectric loss; variation of power factor; effect of ionization loss.

Dielectric Loss-Angle Measurement of Multi-Core High-Tension Cables, With Special Reference to the Schering Bridge, L. G. Brazier. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 414, June 1931, pp. 757-770, 14 figs. Special difficulties of dielectric loss angle; measurement on multi-core cables are examined; conclusion is reached that inter-admittance cannot be considered to have associated with it definite dielectric loss-angle; new method of obtaining inter-dielectric loss-angle in conformity with conclusions of section; wavelength effect appreciably affects apparent dielectric loss-angle when cable exceeds in length small fraction of wavelength.

Cables, Telephone

FAULT LOCATION. Bridge Methods for Locating Resistance Faults on Cable Wires, T. C. Henneberger and P. G. Edwards. *Bell System Tech. Jl.*, vol. 10, no. 3, July 1931, pp. 383-407, 18 figs. Bridge methods for locating resistance faults on cable wires, with special reference to theory of methods for locating insulation faults which cause complete cable failure, locating insulation faults of high resistance, and locating series resistance unbalances.

NOISE ELIMINATION. Telephone Cable Circuit Noise and Power Distribution Systems. *Nat. Elec. Light Assn.—Pub.*, no. 147, July 1931, 4 pp., 5 figs. Results of study made to determine factors involved in power distribution systems and telephone exchange plants which contribute to noise problem; relative influence of various types of power distribution systems and relative susceptiveness of various types of telephone exchange cable circuits are shown.

Circuit Breakers

How Deion and Deion-Grid Circuit Breakers Operate, H. N. Blackmon. *Power*, vol. 74, no. 5, Aug. 4, 1931, pp. 161-163, 8 figs. Two high-voltage circuit breakers, Deion, which is air-break type and Deion-grid, oil-break type, have come into use recently; although both remove ions from arc when interrupting circuit, they operate on entirely different principles.

Clocks, Electric

MOTORS. Measuring 0.000011 Horsepower, T. R. Watts. *Elec. Jl.*, vol. 28, no. 7, July 1931, p. 418, 3 figs. Special spring dynamometer was recently constructed for running speed-torque tests on 200 r. p. m. clock motors of approximately 11 millionths of hp.

Diesel Electric Plants

AUTOMATIC. Automatic Diesel-Electric Plant, E. J. Kates. *Machy. Market*, no. 1604, July 31, 1931, pp. 19-20. Paper before Am. Soc. Mech. Engrs., previously indexed from Advance Paper, for mtg. June 23-26.

Dust Precipitation

ELECTRIC. Harvard Medical Power Extension Precipitates Dust Electrically, G. K. Sauerwein. *Power*, vol. 74, no. 7, Aug. 18, 1931, pp. 226-229, 6 figs. Variety of services applied by Harvard Medical School power plant, which employs electrostatic precipitation of flue dust; design and operating characteristics of boiler plant equipment.

Education

Education for the Engineering Industry, Lond., H. M. Stationery Office, 1931, 67 pp., 1s. 3d. Report of Committee on Education for Engineering Industry and comments on report by educational bodies; factors in recruitment to industry; recruitment from different types of school and from Universities; training in works; promotion in relation to training and instruction; organization of part-time education; subjects of instruction in technical schools and colleges; trade courses; foundry work; instruction in crafts; conclusion.

Electric Drive

Individual or Group, D. C. McGuire. *Elec. Jl.*, vol. 28, no. 8, Aug. 1931, pp. 456-459, 2 figs. For average installation, when all factors have been considered, first cost for individual motor drive and for group drive is approximately same; power and labor costs are more important than first cost; overall efficiency of drive should be accurately determined because cost of power is largest single item entering into cost of operation; various tables showing installation operation costs are given.

New Multi-Speed Drive. *Elec. Jl.*, vol. 28, no. 8, Aug. 1931, p. 490, 2 figs. Movement of handle selects any one of four speeds for driven equipment, constant-speed motor running under full load; drive has motors and gears made in single unit, and is designed for constant horsepower output.

CALENDARS. Synchronizing Operation of Calendar Trains, R. G. Lockett. *Chem. and Met. Eng.*, vol. 38, no. 7, July 1931, pp. 407-409, 3 figs. Control problem centers around necessity of handling group of motors in unison at various speeds and at times arranging for adjustable "draw" between units; rubber-tire fabric calendars ordinarily are driven by two to one d-c. motors operating on two-voltage system, while some forms of textile-printing machines operate on variable-voltage d-c. system providing much greater speed variation.

STEAM POWER PLANTS. Large and Small Motors in the Modern Industrial Steam Power Plant, E. A. Murray. *Eng. and Finance*, vol. 25, no. 1, July 1931, pp. 7-8. General types of electric motors for essential and non-essential auxiliaries in power plant; mechanical construction and control.

Electric Equipment

COAL MINES. Automatic Portable Conversion Equipment at the Wildwood Mine of the Butler Consolidated Coal Co., A. L. Lee. *Gen. Elec. Rev.*, vol. 34, no. 8, Aug. 1931, pp. 459-463, 6 figs. Portable starting and running equipment for portable motor-generator set of 300 kw., 2,300 volts a-c., 275 volts d-c., 1,200 r. p. m.; details of substation.

Electrolytes

The Rapid Determination of Current Efficiency in the Electrolysis of a Zinc Sulfate Electrolyte. *Electrochem. Soc.—Preprint*, no. 60-1, for mtg. Sept. 2-5, 1931, 7 pp., 2 figs. Roasted blende is leached with spent acid sulphate from cell room; before discharging zinc-enriched solution back into cells, it is advisable to test it as to cathode efficiency, which is sensitive indicator of quality of solution; new apparatus and comparatively described have been in satisfactory use for several months.

Engineers

RUSSIA. American Engineers in Russia, J. M. Carmody. *Eng. News-Rec.*, vol. 107, no. 7, Aug. 13, 1931, pp. 262-264. Comments upon engineering status, living conditions, technical problems and future prospects; employment contracts; engineers must be teachers.

Frequency Meters

VACUUM TUBE. A Thermionic Type Frequency Meter For Use Up to 15 KC, F. T. McNamara. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1384-1390, 7 figs. New type of frequency meter which is adapted to measurement of low and intermediate frequencies; instrument absorbs negligible amount of power from circuit being tested, has linear calibration curve and sensitivity of about eight microamperes for one per cent change in frequency; experimental model is described in detail; input is between five and ten volts; other models may require different inputs.

FURNACES. Welding Stresses are Relieved in the Electric Furnace, C. C. Brinton. *Elec. Jl.*, vol. 28, no. 8, Aug. 1931, pp. 478-479, 5 figs. Car-type furnace for use in reducing welding stresses; floor and front wall are mounted on truck that moves in and out of furnace proper; three heater banks are connected star-delta from 60-cycle, 2,300-volt supply source through three 2,300-230/115-volt transformers, with circuits so arranged that each bank may be operated independently; furnace rating is 375 kw., 60 cycle, three phase.

COOLING. Electrical Furnaces with Artificial Atmospheres. *Nat. Elec. Light Assn.—Pub.*, no. 141, July 1931, 9 pp., 16 figs. Value of artificial atmospheres, processes and furnaces which lend themselves to use of artificial atmospheres; gases used and their source of supply; possible future applications; specific uses of artificial atmospheres and functions of gases; illustrations showing furnaces, objects and charges treated, and gas generating equipments.

Fuses

Fuse Performance in Circuit-Interrupting Service, H. D. Braley. *Power*, vol. 74, no. 4, July 28, 1931, pp. 130-133, 11 figs. Fuse considered in its ability to interrupt circuit, and factors that influence its performance in that duty; results of series of overload tests made on different size fuses.

Generators

CONTROL. Automatic Direct-Current Load Shifting Control, L. D. Whitelock. *Elec. Jl.*, vol. 28, no. 5, May 1931, pp. 289-290, 2 figs. Load-shifting apparatus controls d-c. generator voltage instead of placing resistors in bus system; its cost is so reasonable that it is now feasible to install automatic load-shifting equipment in stations which would otherwise be manually operated.

Hydroelectric

POWER DEVELOPMENTS. Hydroelectric Development of the Mokelumne Basin, E. A. Crellin. *Elec. West*, vol. 67, no. 2, Aug. 1, 1931, pp. 54-62, 18 figs. Highest of its kind, Salt Springs rockfill dam halts Mokelumne River, impounding water to produce now 71,000 kva., eventually to supply white coal to four plants with 176,000 kva. installed capacity; descriptions of Salt Springs power house, Tiger Creek conduit, and Tiger Creek power house; wiring diagrams are given.

POWER PLANTS. Saluda Development is Rich in New Engineering Features, A. P. Campbell, J. P. Garvin, A. W. Reed, and N. D. Urquhart. *Elec. Jl.*, vol. 28, no. 5, May 1931, pp. 265-268, 7 figs. Plant has added additional 130,000 kw. to generating capacity in South Carolina, besides having created second largest artificial lake in United States, and largest earth filled power dam in world; built for Lexington Waterpower Co. on Saluda River near Columbia, S. C., it will have ultimate capacity of 195,000 kw., at present four 32,500 kw. generators are installed.

Maintaining Equipment in Hydroelectric Plants, J. E. Housley. *Power*, vol. 74, no. 7, Aug. 18, 1931, pp. 239-241, 4 figs. Inspection and maintenance methods that have proved successful and are outgrowth of eleven years' experience on system that has increased in size to where there is now nearly 300,000 hp. installed capacity.

REMOTE CONTROL. Remote-Controlled Hydro Station. *Elec. World*, vol. 98, no. 4, July 25, 1931, p. 154, 1 fig. Remote automatic controls for hydro stations are used very frequently; diagram showing essential features of remote-control system developed and applied by General Control Corp.; operation.

WATER STORAGE. Chart Simplifies Water-Flow Problems, R. Ball. *Power*, vol. 74, no. 6, Aug. 11, 1931, pp. 202-203, 2 figs. By use of storage-reservoir-capacity curve and second-foot scale, problems on available water for power generation are easily worked out.

Lamps

ULTRAVIOLET. A New Source of Ultraviolet Radiation, J. W. Marden and M. G. Nicholson. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 6, July 1931, pp. 592-601 and (discussion) 601-610, 8 figs. partly on supp. plate. Type of mercury vapor ultraviolet lamp, with possibilities; discussion on mechanical construction, electrical characteristics, and development problems encountered; curves, oscillograms and drawings are included; problem of measuring ultraviolet output; brief treatment of ballast devices to be used with lamp is given, and method of adapting these and glow lamp on 115-volt circuit is considered.

Lighting

Physical Characteristics of Sunshine and Its Substitutes, C. E. Greider and A. C. Downes. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 6, July 1931, pp. 561-571, 6 figs. partly on supp. plates. Measurements made of energy distribution of solar radiation throughout spectrum and of its variation with altitude, location and time of year; attempt has been made to correlate these physical data with clinical experience as to best kind of sunlight for health maintenance; biological significance of various portions of sun's spectrum is discussed; comparison between natural sunlight and one type of artificial sunlight. Bibliography.

The Biologically Active Component of Ultraviolet in Sunlight and Daylight, W. W. Coblentz. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 6, July 1931, pp. 572-577. Attention is called to atmospheric pollution by products of combustion of automobiles and oil-burning heaters, which greatly reduce intensity of ultraviolet vitalizing rays of sunlight; biological data are cited showing that, while healing of rickets is possible in strong light from sky, for effective therapeutic results, obtainable by exposure for convenient interval of time, direct exposure to sunlight is essential. Bibliography.

VISION RELATIONSHIP. Seeing, a Partnership of Lighting and Vision, M. Luckiesh and F. K. Moss. Baltimore, Williams and Wilkins Co., 1931, 241 pp., illus., diagrs., charts, $5.00. Seeing depends upon light and lighting, as well as upon eyes and visual sense; yet light and lighting have not yet received much consideration as partner of visual sense, although excellent scientific data pertaining to vision are available; present book aims to remedy this lack, in part, by giving results of extensive research work, covering some twenty years and undertaken to establish scientific principles of seeing. Bibliography. Eng. Soc. Lib., N. Y.

AIRWAY. Requirements for Airdrome and Air-Route Lighting at Present Time, C. E. Ward and W. M. Hampton. *Cinquieme Congres International de la Navigation Aérienne (5th International Congress of Aviation)*, vol. 1, Sept. 1-6, 1930, pp. 192-199. Requirements from viewpoint of pilots and navigators; limits imposed on lighting installation by costs, standardization of apparatus to simplify manufacture, installation and maintenance; responsibility for installation as it concerns governments, municipalities and aircraft operating companies; difference between needs of commercial aircraft operators and private owners of aircraft or amateur pilots. (In English.)

MEASUREMENT. The Photoelectric Measurement and Photographic Recording of Daylight, W. A. Thomson. *Can. Jl. Research*, vol. 4, no. 6, June 1931, pp. 559-564, 7 figs. Method is described by which illumination intensities were measured by photoelectric cell and galvanometer, and continuous photographic record obtained of variations of intensity over period of time during which ground was covered with snow; it was found that remarkable increase in illumination was caused by presence of cloudiness with full sunshine.

ULTRAVIOLET. The Mercury Arc in Hygienic Illumination, L. J. Buttolph. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 6, July 1931, pp. 578-591, and (discussion) 601-610, 14 figs. To meet general conviction that there must be perceptible erythema as evidence of beneficial effect from ultraviolet in hygienic industrial illumination, Cooper Hewitt lamp will be constructed of glass having increased ultraviolet transmission; value of new lamp is predicted graphically from its relative energy distribution, and erythematic effect curves.

Lines

CALCULATION. Line Loss Calculations, S. W. Marshall, Jr. *Gen. Elec. Rev.*, vol. 34, no. 8, Aug. 1931, pp. 472-473, 1 fig. Theoretical, mathematical analysis; calculations are based on assumption of constant value of charging current per mile for transmission line, constant value of transformer exciting current and constant iron loss for load terminal transformers.

DESIGN. Sags and Tensions in Overhead Lines, C. G. Watson. London and New York, Isaac Pitman and Sons, 1931, 192 pp., diagrs., charts, tables, $3.75. Simple methods of determining sags and tensions which are accurate, yet require no further mathematical knowledge than ability to plot and read graphs, and perform simple arithmetical operations; tables and graphs of hyperbolic and catenarian functions of tangents, etc. Eng. Soc. Lib., N. Y.

LIGHTNING PROTECTION. Direct Strokes to Transmission Lines, W. W. Lewis and C. M. Foust. *Gen. Elec. Rev.*, vol. 34, no. 8, Aug. 1931, pp. 452-458, 8 figs. Potential gradients preceding nearby lightning strokes; cloud field gradients during lightning storm; polarity characteristics of breakdown; Lichtenberg figures; protection afforded by lightning rods; variation of Lichtenberg figure streamer length with applied voltage; characteristics of lightning strokes; field records of direct strokes to transmission lines; direct strokes on transmission lines and tripouts; conclusions of analysis.

PROTECTION. Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 5, May 1931, pp. 299-305, 13 figs. Line-fault protection of loop systems analysis pertaining to fault calculations; application of relays; setting of impedance relays.

RELAYS. Theory and Application of Relay Systems—Gound-Fault Protection of Loop Systems—II, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 7, July 1931, pp. 431-435, 16 figs. Ground-fault currents; application of relays; calculation of ground-fault currents.

Theory and Application of Relay Systems—High-Voltage, Single-Circuit Lines, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 8, Aug. 1931, pp. 485-488, 11 figs. Overcurrent relays; directional-overcurrent relays; directional residual ground relay; polyphase directional-overcurrent relay; fault-detector relay schemes; impedance relay; bus protection; pilot wire relaying; various wiring diagrams are given.

VIBRATIONS. Safeguarding from Vibration, E. C. Thompson. *Elec. Light and Power*, vol. 9, no. 8, Aug. 1931, p. 34, 1 fig. Layout gives idea of work done in installing vibrations dampeners on Jordan Dam-Flomaton line of Alabama Power Co.

Loud Speakers

MEASUREMENT. Notes on Loud Speaker Response Measurements and Some Typical Response Curves, B. Olney. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 7, July 1931, pp. 1113-1130, 10 figs. Difficulties in loud speaker measurements; acoustic features of particular indoor measuring system; outdoor testing arrangements whereby double as well as single radiating loud speakers are measured with negligible ground reflection error; over-all electrical fidelity curve of radio receiver is inadequate performance index; electro-acoustic fidelity embracing frequency response of loud speaker is suggested as more informative.

Machinery

TESTING. Short-Duration Temperature Testing of Electrical Machines, W. E. French. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 415, July 1931, pp. 867-874, 9 figs. Method for rapid determination of temperature-rise and time-constant of electrical machinery and apparatus, based on exponential heating and Hak curves, tests are produced showing that there is satisfactory agreement between figures and curves of graphical method by short-duration tests and those obtained by measurement from long heat-runs; theory of Hak curve.

Motors

SPEED REGULATION. Motor Applications for Drives Requiring Speed Changes, E. C. Dieffenbach. *Power*, vol. 74, no. 3, July 21, 1931, pp. 80-83, 7 figs. Because of nature of work speed adjustments are essential in multitude of motor drives, ultimate object being to save power and to speed up production; speed variations with motors may be obtained in many ways, 15 methods being discussed.

Musical Instruments

Electronic Musical Instruments, R. Raven-Hart. *Electronics*, vol. 3, no. 1, July 1931, pp. 18-19, and 42, 1 fig. Holding of international congress on subject of electronic music by European inventors and manufacturers of electronic musical devices shows practical extent to which new musical devices have already progressed in Germany, France and other European countries.

Networks

ANALYZERS. Phase Faults Analyzed on D-C. Calculating Board, C. W. Bohner and G. W. Vaughan. *Elec. World*, vol. 97, no. 23, June 6, 1931, pp. 1068-1071, 4 figs. Single-phase-to-ground shorts create unsymmetrical fault currents in phases; paper exhibits technique in ascertaining from direct-current calculating board zero-positive and negative phase sequence components of dissymmetry.

INVERSION. Inversion of System Resulting from Switching Operations, A. Boyajian and W. J. Rudge. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 436-439, 18 figs. Equivalent impedance network of system may be altogether different in character from normal, during various stages of switching operations; usually these are of no particular consequence, but occasionally destructive conditions are encountered; simplest single-phase circuits susceptible of such phenomena are taken as basis for general exploration of phenomena and are applied to three-phase system.

PROTECTION. Installation Protection, T. C. Gilbert. *Elec. Rev.*, vol. 109, no. 2799, July 17, 1931, pp. 93-94, 3 figs. Rheinisch-Westfalisches Elektrizitatswerk has solved problem of usual protective methods in rural conditions by installation of extremely interesting protective devices, both at substations and also on consumer's premises.

TESTING. Automatic Recording of System Disturbances, J. T. Johnson, Jr. *Elec. Jl.*, vol. 28, no. 8, Aug. 1931, pp. 466-468, 6 figs. Multi-element oscillograph gives complete record of currents and voltages during transient, starting from rest within four cycles.

Oscilloscopes

A New Cathode-Ray Oscilloscope, W. O. Osborn. *Elec. Jl.*, vol. 28, no. 5, May 1931, pp. 322-324, 6 figs. Distinctly new type of oscillograph has been developed; with it recurring phenomena, such as wave shapes of voltage or current can be viewed on a fluorescent screen in ordinarily lighted room; yet complete oscilloscope is contained in cabinet about size of suitcase and is readily portable.

Photoelectric Cell

CONTROL. Photoelectric Relays and Monorail System Speed Mail Handling, H. L. Bohm. *Steel*, vol. 89, no. 5, July 30, 1931, pp. 31-33, 4 figs. Photoelectric tube control for monorail conveyor system designed to handle mail bags in railroad terminal.

MOVING PICTURES. Phototube Circuit Design for Sound-Pictures, C. A. Wyeth. *Electronics*, vol. 3, no. 1, July 1931, pp. 22-23 and 44, 5 figs. In selecting most suitable type of phototube to be used in reproduction of sound from film, many factors, both electrical and mechanical, must be considered; chief among electrical factors are frequency response characteristic, sensitivity, impedance and noise level and mechanical factors are shape and siz of cell, mounting facilities required, and sturdiness of physical construction.

Power Factor

IMPROVEMENT. Power Factor Improvement, J. Sachs. *AEG Progress*, vol. 7, no. 7, July 1931, pp. 139-145, 17 figs. Relation between active and reactive power; reason for power factor improvement and question as to where and by which means power factor should be improved is considered; design and service characteristics of static condensers; brief review of rotary condensers; various methods of improving power factor of induction motors by three-phase exciters, etc., and synchronous induction motor.

Power Factor Correction by Means of Permittors, A. A. Bolsterli. *Ry. Elec. Engr.*, vol. 22, no. 7, July 1931, pp. 178-180, 3 figs. Physical and economic factors involved in use of static condensers for improving power factor; description of 100-kva., 4,000-volt, 60-cycle permittor; 50-kva., 11,000-volt, 25-cycle permittor used for traction systems.

Poles

WOODEN. Life of Butt-Treated Western Red Cedar Poles, R. M. Wirka. *Elec. World*, vol. 98, no. 6, Aug. 8, 1931, pp. 237-239, 4 figs. Long-time test now under way in vicinity of Los Angeles, Calif., indicates that Western red cedar poles well butt treated with creosote by hot-and-cold-bath process will under such service conditions give average life of at least 25 years; where longer life than 25 years is required under similar conditions top treatment seems necessary; specification of preservatives; table showing condition of experimental Western red cedar poles in and around Los Angeles, Calif., after about 21 to 32 years' service.

STANDARDIZATION. New Standard Specifications for Wood Poles, R. L. Jones. *Bell System Tech. Jl.*, vol. 10, no. 3, July 1931, pp. 514-524, 2 figs. Work of Sectional Committee on Wood Poles of American Standards Assn. covering preparation of specifications for northern white cedar, western red cedar, chestnut and southern pine poles is summarized; major problems underlying development of standard ultimate fiber stresses, standard dimension tables and practical knot limitations are discussed and illustrated by supporting tables or figures.

Power Supply

RURAL. Electricity and the Agriculture of the Next Ten Years, E. A. White. *Agric. Eng.*, vol. 12, no. 8, Aug. 1931, pp. 301-305, 4 figs. Present trend in agriculture and predicted influence of electricity during next ten years. Before Am. Soc. Agric. Engrs.

Radio Antennas

MODULATION. Relations Between Modulation and Antenna Current, W. F. Lanternman. *Electronics*, vol. 3, no. 2, Aug. 1931, p. 59, 1 fig. Mathematical analysis pertaining to increase in antenna current due to power in sidebands; tables show increase in antenna current in relation to per cent of modulation.

SHORT WAVE. Developments in Short-Wave Directive Antennas, E. Bruce. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1406-1433, 23 figs. Relative importance of factors which limit intelligibility of short-wave radio telephone communication; more important of these factors are inherent set noise, external noise (static, etc.), and signal fading; possibility of counteracting these limitations through antenna directivity is indicated; antenna system which maintains desirable degree of directivity throughout broad continuous range of frequencies is described.

The Determination of Power in the Antenna at High Frequencies, A. H. Taylor and H. F. Hastings. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1870-1883, 9 figs. Brief review of general methods of measuring radio-frequency power in antenna; series of tests on particular transmitter operating from 4,000 to 26,000 kc.; tests indicate that it is reasonable for such transmitter continuously variable in frequency and of fairly modern design to be expected to put not less than 50 per cent of its input plate power of last stage into antenna as radio frequency from 4,000 kc. to 8,000 kc. and not less than 82 per cent at 24,000 kv.

Radio Engineering

Experimental Radio Engineering, J. H. Morecroft. N. Y., John Wiley and Sons, 1931, 345 pp., illus., diagrs., charts, tables. $3.50. Laboratory course in principles of radio; 51 experiments are given, designed to bring out characteristics of component parts of receiving and transmitting apparatus, and there is an introduction upon laboratory apparatus. Eng. Soc. Lib., N. Y.

Foundations of Radio, R. L. Duncan. N. Y., John Wiley and Sons, Inc., 1931, 246 pp., illus., diagrs., tables. $2.50. An introductory textbook on electricity, covering in non-mathematical language fundamentals of interest to student of radio engineering. Eng. Soc. Lib., N. Y.

Radio Frequency

MEASUREMENT. Measuring the Frequencies of Radio Signals, A. A. Roetken. *Bell Laboratories Rec.*, vol. 9, no. 12, Aug. 1931, pp. 585-588, 2 figs. By beating incoming radio signal down in successive known steps, its frequency can be accurately determined with audio-frequency oscillator; equipment at Holmdel is illustrated and described.

Radio Receivers

CRYSTAL CONTROLLED. Application of Piezo-Electrical Crystals to Receivers, R. R. Batcher. *Electronics*, vol. 3, no. 2, Aug. 1931, pp. 57-58, 4 figs. Analysis of quartz crystal bridge circuit in intermediate frequency amplifier of super-heterodyne receiver and development of simple relation between degree of unbalance and impedance of quartz crystal and holder which governs response of bridge as whole; it is shown that almost all of one sideband is eliminated but that other gets through to transmit desired modulation.

Radio Waves

ATTENUATION. Investigation of the Attenuation of Electromagnetic Waves and the Distances Reached by Radio Stations in the Wave Band from 200 to 2,000 Meters, H. Fassbender, F. Eisner and G. Kurlbaum. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1446-1470, 25 figs. Results of large number of field strength measurements in which relative radiation characteristics of transmitting and receiving stations remain constant even on changing their distance; constant of attenuation as function of wavelength was determined for propagation of waves over land from these measurements; method used eliminates errors in absolute determination of received field strength.

PROPAGATION. Radio Transmission Studies of the Upper Atmosphere, J. P. Schafer and W. M. Goodall. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1434-1445, 9 figs. Number of measurements which show time variations in virtual height of ionized regions of upper atmosphere; these measurements were usually made simultaneously on two frequencies, 1,604 kc. and 3,088 kc.; single frequency data are also given; main points of interest are presented.

Railroad

SIGNALS AND SIGNALING. Positive Control by the new Quebec Tunnel Signal System, E. S. Taylor. *Elec. News*, vol. 40, no. 15, Aug. 1, 1931, pp. 39-40, 4 figs. Mile-long tunnel has just been completed by Canadian Pacific Railway as direct link between its main line and new round-house for its great White Empresses, at Wolfe's Cove, Quebec; one of interesting features of this new project is unique and modern signal system for safety and guidance of trains into and out of Quebec, and also for those which use tunnel; system is briefly described.

Indianapolis Union Station Installs Electro-Pneumatic Interlocking. *Ry. Signaling*, vol. 24, no. 8, Aug. 1931, pp. 265-268, 6 figs. Nearly 200 train movements each day are now made with greater safety and flexibility; features of interlocking machine, signals, field apparatus, power supply and air supply.

Centralized Traffic Control Installed on Wabash. *Ry. Signaling*, vol. 24, no. 7, July 1931, pp. 231-236, 7 figs. Outstanding features of centralized control traffic installation on 37 mi. of single track line on Wabash railway between LaFayette Junction, Ind., and State Line; track layout and traffic; dispatcher's machine 93 mi. from distant end of 37 mi. single-track installation; operating savings justify cost; special signal requirements; power supply system.

New Interlocking on the Toronto, Hamilton and Buffalo at Hamilton, Ont. *Ry. Signaling*, vol. 24, no. 7, July 1931, p. 245, 5 figs. Old layout replaced by 72-lever plant; new cable distribution constructed under traffic without stopping train; interlocking machine and tower.

New Interlocking for the St. Louis Municipal Bridge. *Ry. Signaling*, vol. 24, no. 8, Aug. 1931, pp. 280-282, 5 figs. Simplicity of circuit arrangement and unique tower are features of 64-lever electric plant; battery and power room; relay room.

Interlocking. *Am. Ry. Signaling Principles and Practices*, Chapter 16, 1931, 65 pp., 43 figs. Definitions; types; historical review; application; track layout; layout and operating features of inside apparatus; 361 questions dealing with interlocking.

SUBSTATIONS. Habitant Style Disguises City of Montreal's Latest Automatic Railway Substation. *Elec. News*, vol. 40, no. 15, Aug. 1, 1931, pp. 31-32, 4 figs. Fourth mercury-arc rectifier substation installed by Montreal Tramways Co. contains two 1,500-kw., 12-phase, 600-volt units; station and equipment are described.

Rate Making

POWER INDUSTRY. A Composite Block Tariff, L. G. Hill. *Elec. Rev.*, vol. 109, no. 2798, July 10, 1931, p. 47, 3 figs. Lack of suitable standard tariff is probably greatest obstacle to domestic electrical development; what engineer has to pay for his bulk supply and how best these charges can be applied to domestic consumers; teaching the consumer to think in terms of hundreds of kilowatt-hours.

Reactors

CURRENT LIMITING. Development of Large Current-Limiting Reactors, R. B. George. *Elec. Jl.*, vol. 28, no. 8, Aug. 1931, pp. 460-463, 10 figs. Design development and testing procedure of dry-tube and oil-immersed current-limiting reactors; increased reactor sizes.

Rectifiers

MERCURY ARC. Mercury-Arc Rectifiers, W. E. Gutzwiller. *Power*, vol. 74, no. 2, July 14, 1931, pp. 44-47, 6 figs. Analysis of rectifier performance compared with that of synchronous converters and motor-generator sets.

VOLTAGE REGULATION. Voltage Regulation in Rectifier Plants, N. Kotschuboy. *Brown Boveri Rev.*, vol. 18, no. 7, July 1931, pp. 223-233, 22 figs. By production of new tapping switches permitting number of steps to be increased up to 60, it was possible to limit use of induction regulators to infrequent cases; automatic control of such tapping switches greatly simplifies operation of rectifier plants, thus enabling important savings to be made.

Registration

Important Changes Proposed in Uniform Registration Law, T. K. Legare. *Eng. News-Rec.*, vol. 107, no. 7, Aug. 13, 1931, pp. 266-267. President, National Council of State Boards of Engineering Examiners, recommends definite educational qualifications for professional engineers and land surveyors; satisfactory definition of engineering sought.

Steam Electric Plants

HIGH PRESSURE. Station "A" Initiates Use of High-Pressure Steam in the West, W. G. McKay and O. E. Steinbeck. *Elec. West*, vol. 67, no. 2, Aug. 1, 1931, pp. 68-71, 3 figs. Boiler pressures of 1,400 lb. are used in new steam station of Pacific Gas and Electric Co. in San Francisco; 100,000 kva. is generated by two turbine-generator sets recently installed to supply increased energy requirements of Bay area.

Steel Corrosion

UNDERGROUND. The Electrolytic Corrosion of Underground Metallic Structures by Stray Currents, O. M. Longfield. *Instn. Engrs. Australia—Jl.*, vol. 3, no. 5, May 1931, pp. 157-168, 21 figs. Nature of electrolysis of subsurface structures and conditions bringing it about; discussion of field surveys, results obtained, and to what extent observed phenomena can be used as estimation of damage; remarks about instruments for use in field, and in particular of slow speed oscillograph adapted by author; mitigative measures are critically discussed; importance of protective coatings for steel mains is stressed.

Substations

AUTOMATIC. 10 Years' Experience with Automatic and Supervisory Distribution Substations, F. F. Ambuhl. *Elec. News*, vol. 40, no. 15, Aug. 1, 1931, pp. 35-37 and 51, 5 figs. Toronto Hydroelectric System has long realized advantages and economies of automatic and supervisory control; as result, all new stations built since 1920 have been designed for either automatic or supervisory control; automatic controls have given fairly satisfactory results and supervisory controls have given excellent results, especially cable type supervisory. Before Am. Inst. Elec. Engrs.

REMOTE CONTROL. Synchronism Checked by Voltmeter, F. M. Lewis. *Elec. World*, vol. 97, no. 23, June 6, 1931, p. 1056, 1 fig. Northwestern Electric Co. completed substation in business district of Portland which will be remotely controlled until station becomes large enough to require an operator; to save expense of installing additional control wires; synchroscopes; synchronizing switches or synchro-verifier relays; special voltmeter connection for checking synchronism between line and bus was made.

Visicode Supervisory Control, L. J. Cissna. *Elec. Jl.*, vol. 28, no. 7, July 1931, pp. 424-425, 3 figs. Visicode provides remote control of equipments in several distant stations with continuous indications for each piece of apparatus controlled, over only two line wires, and also makes possible selective remote-motoring indications over same two wires used by supervisory control, as well as operation of number of remote stations in parallel on same two wires; most important feature of visicode is that it reduces line wire costs to minimum not possible with previous three- and four-wire designs.

Switchgear

METAL-CLAD. Guide for Specification Covering Metal-Clad Switchgear. *Nat. Elec. Light Assn.—Pub.*, no. 149, July 1931, 3 pp., 1 fig. Guide is primarily intended to serve as reminder of points to be covered when purchasing equipment and as indication of logical order in which they should be enumerated; five different unit standards are presented.

Synchronizers

AUTOMATIC. A Thermionic Automatic Synchronizer, F. H. Gullikson. *Elec. Jl.*, vol. 28, no. 7, July 1931, pp. 421-423, 4 figs. New synchronizer requires but five volt-amperes per transformer for its operation, which is well within limits of energy which can be drawn from potential devices, making transformers unnecessary; this makes possible automatic synchronization in some applications where it was not previously justified economically; synchronizer uses two thermionic tubes which, because they are in use only during synchronization, have life of five to ten years.

Telephone

AUTOMATIC. Dial Offices for Small Communities, F. T. Meyer. *Bell Laboratories Rec.*, vol. 9, no. 12, Aug. 1931, pp. 562-566, 5 figs. Adaptation of improved telephone equipment to smaller communities, especially those more or less isolated from larger operating centers, has been greatly facilitated by development of new dial office of step-by-step type; equipment is described in some detail.

The Bypath Automatic Telephone, E. P. G. Wright and J. H. E. Baker. *Post Office Elec. Engrs.—Jl.*, vol. 24, pt. 2, July 1931, pp. 116-124. Bypath system is universal automatic telephone system employing single motion switches (or uniselectors) of simple design; development of system has been carried out entirely in London and is outcome of unremitting research work extending over number of years resulting in production of system which, in opinion of authors, is superior to other step-by-step systems; in this class it achieves standard of efficiency hitherto unattained.

DIAPHRAGM MEASUREMENT. Recording Contour Gauge, E. C. Erickson. *Bell Laboratories Rec.*, vol. 9, no. 12, Aug. 1931, pp. 567-570, 6 figs. Equipment for measurement of quality and adjustment of diaphragm; photographic record of two diaphragms are given.

LONG DISTANCE. Speed of Service on Long Distance Calls, C. Bryon. *Telephony* vol. 101, no. 3, July 18, 1931, pp. 25- and 28-29, 1 fig. Average time required to complete toll call is 1.6 min. compared with eight min. in 1926; some principles for obtaining and maintaining speed of service. Paper before Annual Traffic Conference, III.

RELAYS. Characteristics of Strowger Relays—III, K. W. Graybill. *Telephone Engr.*, vol. 35, no. 7, July 1931, pp. 32-33, 3 figs. Various methods used to determine mechanical adjustment values of horizontal relays; reference tables governing these values.

REPEATERS. Repeaters for Two-Wire Toll Circuits, R. L. Case. *Bell Laboratories Rec.*, vol. 9, no. 12, Aug. 1931, pp. 579-584, 10 figs. Twenty-one type repeater employs but single amplifying element and is limited in its use by requirement that lines in opposite directions must balance each other; employment of balancing networks, and two amplifying element results in broader applicability of 22-type repeater; simplified schematic diagram of 22-A-1 repeater; loss-frequency characteristics and gain-frequency characteristics of equipment described are given.

Negative Impedances and the Twin 21-Type Repeater, G. Crisson. *Bell System Tech. Jl.*, vol. 10, no. 3, July 1931, pp. 485-513, 16 figs. Negative resistances and impedances; their properties and some devices by which they may be produced physically; certain properties of negative impedances when used as series and shunt boosters for amplifying speech waves in telephone circuits; description of circuit and properties of twin 21-type repeater.

STATISTICS. World's Telephone Statistics, January 1, 1930. *Bell Telephone Quarterly*, vol. 10, no. 3, July 1931, pp. 138-149, 7 figs. Statistical data, tables, curves and maps.

TESTING. Automatic Testing Equipment for Trunk Circuits, T. R. Lundius. *Bell Laboratories Rec.*, vol. 9, no. 12, Aug. 1931, pp. 589-592, 2 figs. To make sure that supervisory relays are functioning properly they are frequently tested, and since there are large numbers of them to simplify and quicken procedure, automatic circuits have recently been developed which operate relays under conditions more severe than are ordinarily met in service.

Television

PICK-UP. Television Direct Pick-up Camera, D. W. Short. *Electronics*, vol. 3, no. 2, Aug. 1931, p. 69, 1 fig. Novel method of "picking up" television images is made possible by means of direct pick-up camera; this device differs from indirect pick-up method or so-called flying spot equipment, inasmuch as image of person or object being televised is focused directly upon spiral number one of scanning disk.

Transformers

CONSTANT CURRENT. Simple Automatic Time Control for Constant-Current Transformers, W. H. Colburn. *Elec. World*, vol. 98, no. 5, Aug. 1, 1931, pp. 202-203, 3 figs. Control described has been devised to meet following operating requirements; start at predetermined time and continue to operate until cut out, at predetermined time; cut out and lock out individual transformer or main breaker in event of electrical failure in one or in totality circuit; etc.

EXTINGUISHING COILS. Determination of the Rating of Extinguishing Coils Which May Be Connected to Transformers, A. van Gastel. *Brown Boveri Rev.*, vol. 18, no. 8, Aug. 1931, pp. 251-259, 14 figs. Design analysis, diagrams, characteristics and equations.

Vacuum Tubes

CONSTANTS. Graphical Representation of the Three Constants of a Triode, I. Miura. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1488-1491, 2 figs. It is shown that three constants of triode, e. e., amplification factor, internal resistance, and transconductance can be represented by one point in equilateral triangle logarithmically scaled; as example, graph in which are plotted constants of 24 kinds of typical tubes now used in practise is given.

PENTODES. Performance of Output Pentodes, J. M. Glessner. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 8, Aug. 1931, pp. 1391-1405, 17 figs. Comparison of power output, distortion, power sensitivity, and a-c./d-c. power economy of group of experimental pentodes is made with corresponding triodes; apparatus and method of measuring are described; pentodes' a-c./d-c. economy and power sensitivity is considerably higher than that of corresponding triodes; harmonic distortion is found to be generally worse with pentodes; variation in power output with changes in load resistance, arbitrarily called "output distortion," is shown to be about same for both classes of tubes.

ULTRA SHORT WAVE. Tubes for Generating 18-cm. Waves. *Electronics*, vol. 3, no. 1, July 1931, p. 4, 1 fig. Photograph of tube used in transmission of radio phone communication across English channel by means of directive wave of order of 18 cm. published for first time.

VOLTAGE REGULATORS. Tube Voltage Regulator Eliminated Hunting Tendency, F. H. Gulliksen. *Elec. World*, vol. 98, no. 4, July 25, 1931, pp. 162-163, 2 figs. Thermionic type voltage regulator for d-c. generators has recently been developed, by which anti-hunting force should be proportional to rate of recovery of regulated voltage, and must be zero when regulated voltage is normal at any generator load; anti-hunting adjustment should be simple and independent of adjustment for regulated voltage and regulator response.

Watt-Hour Meters

BEARINGS. An Investigation of Problems Relating to the Use of Pivots and Jewels in Instruments and Meters, V. Stott. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 414, June 1931, pp. 751-756, 13 figs. Results obtained in investigation of problems arising in connection with use of pivots and jewels for bearings; means adopted for obtaining accurately shaped pivots and for measurement of pivots and jewels; method of measuring hardness and determining suitable radii of curvature.

CALIBRATION. Determining Large Three-Wire Lighting Meter Constants, H. W. King. *Elec. World*, vol. 98, no. 5, Aug. 1, 1931, pp. 201-202, 7 figs. Simple but infallible method of determining or checking dial constants in cases where self-contained meters with dial constant equaling one, may be used with current transformers and then have new multiplying constant assigned and marked on dial in meter shop.

Waves

ANALYSIS. High-Voltage Surge Testing, P. H. McAuley. *Elec. Jl.*, vol. 28, no. 5, May 1931, pp. 278-280 and 305, 10 figs. Analysis of laboratory data; interpretation of oscillograms; time lag of breakdown; obtaining time-lag curves from oscillograms; laboratory data required.

Welding

Twenty-Five Years of Electric Welding, P. W. Fassler. *Am. Welding Soc.—Jl.*, vol. 10, no. 5, May 1931, pp. 29-35, 8 figs. History of welding; fundamental thermal and electrical laws which have vital bearing on design of welding machines; butt welding; spot welding; relief welding; seam welding.

ARC. Automatic Arc-Welding: Its Advantages and Limitations, A. M. Candy. *Elec. Jl.*, vol. 28, no. 7, July 1931, pp. 415-417, 6 figs. General outline of process and equipment.

ARC—ATOMIC HYDROGEN. High Tensile Atomic Hydrogen Arc Welds in Alloy Steels, F. Ray. *Am. Welding Soc.—Jl.*, vol. 41-45, 11 figs. Welding procedure in making Flexo Disc expansion joint which consists of steel bellows constructed of corrugated steel discs welded together at their inner and outer peripheries; properties of weld.

BOILER MANUFACTURE. Attitude of Eleven Utilities Toward Welded Boilers. *Elec. World*, vol. 97, no. 21, May 23, 1931, pp. 955-957, 1 fig. N. E. L. A. prime movers committee has given welded boiler drums and tubes considerable study and A. S. M. E. boiler code committee is now engaged in formulating code that permits such construction; several utility executives and engineering or operating department heads were asked three questions treated later to ascertain possible trend of welded boiler acceptance and also what active cooperation might be expected from users in bringing about code acceptance.

PIPE LINES. Design for Welded Piping, A. G. Wikoff. *Am. Welding Soc.—Jl.*, vol. 10, no. 5, May 1931, pp. 26-28, 9 figs. Standard designs for various types of joints recommended for welded piping systems; developed by Linde Air Products Co.; open single vee butt welds; open square butt weld; closed single vee butt weld; welded coupling; butt weld with thin liner; special reinforced joints.

Welding Machines

ARC. The Burke-Scott Electric Welder. *Engineer*, vol. 152, no. 3939, July 10, 1931, p. 48, 2 figs. Although primarily intended for arc welding, it may be used for other purposes that call for similar operating characteristics; machine may be regarded as one in which main pole parts are split into two parts, one part being shunt-wound and other series-wound.

Welds

GAMMA RAY ANALYSIS. Inspection of Welds with Gamma Rays, G. E. Doan. *Am. Soc. Steel Treating—Preprint*, no. 34 for mtg. Sept. 21-25, 1931, 8 pp., 5 figs. Gamma-ray method gives adequate results for inspection of welds, according to tests made by author at Lehigh University; tests on good welds and bad welds revealed each kind without fail; not only were defects plainly visible in bad welds, but good welds were revealed as sound, in each case.

X-RAY ANALYSIS. X-Ray Inspection of Welds, H. R. Isenburger. *Am. Welding Soc.—Jl.*, vol. 10, no. 5, May 1931, pp. 17-21, 15 figs. Inspection methods and equipment of St. John X-Ray Service Corp., New York; diagram of exposure technique for small tubing inspection; diagram of fluoroscopic x-ray inspection; operating cost is $3 to $5 per hour.

Industrial Notes

A New Clip-On Ammeter.—Ferranti Electric, Limited, Toronto and New York, has developed a new instrument known as the Clip-On Ammeter, which may be used for determining the actual loading of transformers, for balancing secondary transformer loads on three-wire services, or for checking power consumers' loads. It will also be of value to electrical contractors and plant electricians in determining actual loads taken by individual motors, or balancing loads on different circuits or feeders. It consists of a split-core current transformer with the secondary connected to a high grade, well damped Ferranti milliammeter calibrated for direct reading in amperes. The operating handle is well insulated. Good accuracy is provided even at low currents because of the low burden of the meter, which is only 0.22 voltampere. This is a feature not found in any other typ eof such equipment.

This instrument affords a rapid and convenient method of measuring the current in any a-c. leads or bus-bars without disconnecting them for the insertion of the usual current transformer or ammeter leads. The meter has a double range, one scale being 0-100 amperes and the other 0-500 amperes. A switch on the meter changes the reading from one scale to the other. The instrument is light and can be operated easily with one hand.

Ohio Brass Promotes H. H. Crow.—Announcement has been made by the Ohio Brass Company, Mansfield, Ohio that H. H. Crow, with headquarters at the New York office, is now in charge of its sales territory in upper New York state. He will handle the sale of high tension insulators and electrical porcelain to the power companies in that locality.

Oil-Blast Principle Applied to Low Capacity Breakers.—The General Electric Company has announced a new line of triple-pole circuit breakers for outdoor service designated Type FKO-60. These breakers can be furnished mounted on self-supporting steel framework or for pole-mounting, and for manually-, solenoid-, or motor-operated requirements. The interrupting rating is 50,000 kva., equipped with blade-and-finger contacts, using the plain-break principle of arc interruption. Each pole is in a separate oil tank. The Types FKO-60B and FKO-60C breakers have interrupting ratings of 100,000 and 175,000 kva. respectively. They have separate oil tanks for each pole and operate on the oil-blast principle. An insulating chamber is fitted within each tank. In each chamber an exhaust port is located adjacent to one of the breaks in each phase. A pressure is set up within the oil by the arcing of the contacts. The only vent for this oil under pressure is through the exhaust port.

An Improved Type of Switchboard Matting.—The Diamond Rubber Company, Akron, Ohio, announces an improved insulation matting for use as a protection to the operators of power switchboards, that is guaranteed when tested in accordance with the methods prescribed in American Society For Testing Materials Specification D-178-24, to withstand the following tests: Voltage Test—Thicknesses of 1/8", 3/16", 1/4" and 3/8" will withstand a potential of 15,000 volts for one minute when tested between electrodes consisting of rectangular metal sheets or plates 9" x 15" in size, or of equivalent area. Dielectric Test—When a section of the matting is tested in air between disc electrodes 2" in diameter, it is guaranteed to withstand the following voltage: 1/8" thickness 20,000 volts; 3/16" 30,000 volts; 1/4" 40,000 volts; 3/8" 45,000 volts. The matting is made with six laminations of high grade rubber, and a ply of fabric to give additional strength.

New Protective Feature for Street Lighting Lamps.—The Westinghouse Lamp Company announces the development and perfection of a protective short-circuiting device, the "Inbuilt Cutout" which, supplemental to the regular construction, may be built into the base of Mazda incandescent lamps designed for burning on series circuits. In addition to the greater convenience of relamping after burnout, lamps with Inbuilt Cutouts possess two notable advantages—

First, it serves as a completely reliable means for quenching the arc which, upon burnout of the filament, has occasionally persisted. In rare instances such arcs have continued to a point where the socket and even the post top has been destroyed. Second, because it operates with lesser variation from designed breakdown voltage than is the case with short-circuiting filaments, discs or materials heretofore employed, the Inbuilt Cutout makes it possible successfully to operate small series circuits of only a few lamps. This is sometimes of considerable advantage in supplying street lighting service for newly added, outlying territories.

Gilbert Gislason Joins U. S. Magnetic Products Corp.—According to a recent announcement, Gilbert Gislason has been appointed special representative of the Great Lakes District and also in upper New York State, for the U. S. Magnetic Products Corp., Lock Haven, Pa., manufacturers of coil windings, solenoids, transformers, etc. Mr. Gislason was previously connected with the Easton Coil Co., Easton, Pa., and in his new connection he again becomes associated with N. L. Dinion. A few months ago Mr. Dinion resigned as president of the Easton Coil Co., to become vice-president of the U. S. Magnetic Products Corporation.

Kester Solder Opens Canadian Plant.—The Kester Solder Company has announced the opening of a new plant at Brantford, Canada, on September 15. The plant will be operated under the name of Kester Solder Company of Canada, Ltd. Other factories are located at Chicago and Newark, N. J.

Trade Literature

Lava.—Bulletin, 24 pp. Describes lava and magnesia specialty insulation. This material has very high dielectric strength and will withstand extremely high temperatures. It is widely used by electrical manufacturers as an insulator in many forms. Lava products are produced with the same degree of accuracy and interchangeability as those of a screw machine and without the necessity of first making dies or molds. American Lava Corporation, 27 William St., Chattanooga, Tenn.

Motor Starter.—Bulletin, 4 pp. Describes a new EC&M oil-immersed starter for motors of large horsepower. Like the No. 1 type ZO starter, this larger starter is a self-contained unit, totally enclosed in a heavy pressed steel case with oil-immersed main and control circuit contacts, and vapor-proof overload relays. If desired, installation of such starters can safely be made alongside the motors controlled. The Electric Controller & Mfg. Company, 2700 East 79th Street, Cleveland, Ohio.

Celoron Gears.—Bulletin, 28 pp. Describes Celoron silent gears and illustrates their application in various types of machinery. Continental-Diamond Fibre Company, Newark, Delaware.

Trimming Board.—Bulletin. Describes a new and improved cutter for use in drafting rooms, engineering schools, and for cutting insulating materials or other sheet materials. An automatic hold-down clamp works through the movement of the 26-inch blade in advance of the shearing. No wood is employed in the construction, the top being of Bakelite with engraved quadratic lines one inch apart over its entire surface. Bosch Products Company, San Francisco, and 370 Lexington Ave., New York.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 11

The JOURNAL of the A.I.E.E. for November 1931

C. E. SKINNER, *President*
F. L. HUTCHINSON, *National Secretary*

Publication Committee

E. B. MEYER, *Chairman*
W. S. GORSUCH   F. L. HUTCHINSON
W. H. HARRISON   H. R. WOODROW

Publication Staff

GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in ELECTRICAL ENGINEERING are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

REPUBLICATION from ELECTRICAL ENGINEERING of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index.

Printed in the United States of America. Number of copies this issue—

24,000

This Month—

Front Cover

Lower Leevining Creek hydroelectric plant of the Southern Sierras Power Company, California.
—Electrical West Photo.

Field Studies of Arcing Faults on Power Lines 857
By J. R. EATON, J. K. PECK, and J. M. DUNHAM

Why Apply Science? 861
By H. E. HOWE

Electric Analogs for Difficult Problems 862
By H. H. SKILLING

Power Equipment at KDKA's New Station 865
By R. L. DAVIS

Reactance of Lines With Ground Return 868
By J. E. CLEM

Circle Diagrams for Short Lines 871
By T. D. OWENS

Simplicity and Economy of Oil Filled Cable 874

Economics of High Voltage Cable 874
By D. W. ROPER

Layout of Oil Filled Cable Systems 878
By G. B. SHANKLIN and F. H. BULLER

Accessories for Oil Filled Cable 880
By R. W. ATKINSON and D. M. SIMMONS

The Transfer of Skill to Russia 883
By WALTER N. POLAKOV

Unity Power Factor for Neon Tube Signs 886
By J. K. McNEELY and R. R. LAW

—— Turn to Next Page

Operating Experiences with Automatic and Supervisory Control . . . 888

Automatic Control of Substations 888
By GARLAND STAMPER

Automatic and Supervisory Control of Substations . . . 890
By F. F. AMBUHL

Supervisory Automatic Control of a Generating Station . 892
By R. M. STANLEY

Communication in the New Waldorf Astoria 895

Corona Versus Conductor Surface 898
By W. D. WEIDLEIN

Abstracts of Papers Presented at the Kansas City Meeting 900

Electric Arc Welding in Building Construction—Vinther . . . 900
Effect of Wave Form on Induction Relay Operation—Robinson . . 900
A Telegraphic Pilot-Wire Relay System—Frier 900
Calculating Load Division in Distribution Systems—Almquist . . 900
Overvoltage Caused by Dropping Load—Burnham 900
Backfires in Mercury Arc Rectifiers—Slepian & Ludwig 901
Impulse Tests on a 4.8-Kv. Substation—Collins, Piepho & Torok . . 901
Interconnection of the 25- and 60-Cycle System of the Union Electric Light & Power Co.—Nelson & Hough 901
Automatic Control for Frequency Converters—Shively & Whitlow . 901
Forecasting Population for Engineering Purposes—Holsen . . . 902
Advance Planning of Telephone Facilities—McFarland 902
Tape-Armored Telephone Toll Cable—Nystrom 902
The Time Factor in Telephone Transmission—Blackwell 902
Lightning Disturbances on Transmission Lines—Jackson & Warner . 903
Corona Energy Loss—Weidlein 903
Application of Primary Distribution Fuses—Sanford 903
The Expulsion Fuse—Slepian & Denault 903
Fuse Cut-Outs for A-C. Distribution Circuits—Newton 903

Short Item—

Compact Industrial Control 885

News of Institute and Related Activities . . 904

Letters to the Editor 909
Local Institute Meetings 914
Employment Notes 918
Membership 919
Engineering Literature 921
Industrial Notes 926
Officers and Committees (For complete listing see p. 771-776, September 1931 issue of ELECTRICAL ENGINEERING.)

PLANS already are being made for the 1932 A.I.E.E. winter convention. (*See p. 908-9.*)

POWER equipment of unusual design and proportions was required for KDKA's new high power transmitter. (*See p. 865-8.*)

HOUSED in the new Waldorf-Astoria Hotel in New York is an electrical program distribution system involving many novel features. (*See p. 895-7.*)

INCREASED attention now is being focused upon oil filled cable and upon means of simplifying its installation, for transmitting electric power at high voltages. (*See p. 874-82.*)

DISCUSSION on a variety of articles published in ELECTRICAL ENGINEERING has come to the editor during the past month. Some of these may be found in this month's "Letters to the Editor" columns. (*See p. 909-10.*)

ABSTRACTS of the eighteen technical papers presented at the recent Kansas City District meeting are given in this issue, in order that interested parties may order copies of the complete papers without delay. (*See p. 900-3.*)

REVERSING the usual order by setting up electrical analogies for complicated mechanical systems, sometimes provides a simpler method of solution for solving difficult mechanical problems. (*See p. 862-5.*)

WITH 25 years' professional engineering experience in the U. S. A. and a recent eighteen-month engagement in the U.S.S.R., a native of Russia gives some interesting sidelights on that country's much discussed industrial development. (*See p. 883-5.*)

EDISON, the newsboy, telegrapher, inventor, creator of innumerable devices and processes underlying in no small way the modern commercial and industrial development of the world, has been cited for his Final Reward. His life's work has had great effect on pure and applied sciences. His dominating motive was creation. His indomitable will and devotion to his work will stand as historical monuments to inspire and to encourage those who follow. The Institute with the world mourns his passing. (*See p. 904-7.*)

Field Studies of Arcing Faults on Power Lines

Experimental studies of arcing faults on a 75-kv. transmission system indicate that a lightning flashover is most likely to develop into a power arc when power current is flowing past the flashover point, when normal-frequency voltage is increased, or when line insulation is decreased.

By
J. R. EATON Consumers Pwr. Co. Jackson, Michigan
Associate A. I. E. E.
J. K. PECK National Elec. Lt. Assn., New York
Associate A. I. E. E.
J. M. DUNHAM American Tel. & Tel. Company, New York
Associate A. I. E. E.

A DISCUSSION of the continuity of service which can be maintained on a power system frequently involves the consideration of power arcs. In spite of the acknowledged importance of arcs in the operation of power systems, there is but little available experimental information concerning the causes of power arcs which follow surges, the characteristics of arcs, or the resulting effects of arcs. The results of cooperative experimental investigations made by the Consumers Power Company, Jackson, Mich., the General Electric Company, and the joint development and research subcommittee of the National Electric Light Association and Bell system, to study the character of arcing faults are discussed here.

Factors Governing the Power-Arc Development

Operating data presented in the past few years have indicated that lightning frequently may cause sparkover of transmission-line insulators without producing a power arc. Although the spark and the arc are quite different in nature, there is no sharp line of demarcation between the two, and the transition from one to the other is but little understood.

To investigate experimentally the factors governing the transition of an impulse flashover into a power arc, impulses from a 1,500-kv. lightning generator were applied to a transmission-line conductor energized to ground through a transformer bank. The line insulation was such that in every case flashovers occurred at a predetermined test tower where the amount of insulation was varied at will. The length of the transmission line beyond the test tower could be changed from a few feet to 35 mi.; with the 35-mi. line the total charging current of the three-phase line flowed past the flashover point, thus simulating a load on the line.

The curves shown in Fig. 2 give the results of 278 tests in which the applied 30-cycle voltage, the flashover distance, and the condition as to whether or not current was flowing past the flashover point were varied. The point on the 30-cycle voltage wave at which flashover occurred was governed merely by chance. These curves show that for a given electrode spacing and excitation voltage, power-arc follow-up is more likely to occur when current is flowing past the sparkover point. The explanation for this probably lies in the fact that current is immediately available for maintaining the power arc without having to overcome the inductance of the circuit. The curves show also that for a given electrode spacing, the possibility of power-arc follow-up is dependent upon the value of normal frequency excitation voltage.

During 66 of the tests oscillograms of voltage and current in the transmission line were obtained, from which could be determined the point on the 30-cycle voltage wave at which flashover occurred. Results of these tests showed that a high percentage of flashovers occurring near the 90-deg. point of the voltage wave resulted in power arcs. From a further analysis it was found that this grouping of tests near the 90-deg. point was very definite for tests in which current was flowing past the sparkover point, but when there was no current in the line the points were fairly well scattered.

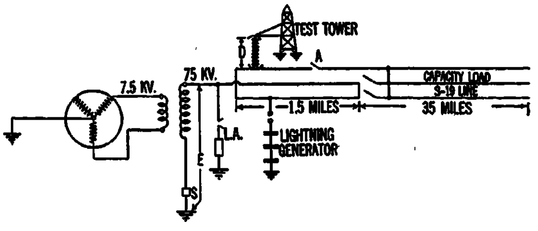


Fig. 1. Diagram of connections used in field flashover tests

Distance D between conductor and tower variable. With line off, switch A was open; with line on, switch A was closed

---

From "Experimental Studies of Arcing Faults on a 75-Kv. Transmission System," (No. 31-102) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

It is possible that on systems having large connected generating capacities carrying heavy loads, with the consequent immediate availability of large currents, the per cent of sparkovers developing into power arcs may be much higher than is indicated by these tests.

Characteristics of Power Arcs

In connection with relaying and short-circuit computations it is desirable to know, under certain fault conditions, something regarding the characteristics of power arcs. From the results of some 30 tests made under various conditions, some information has been obtained regarding the variations in arc resistance, wave shape, persistence, length, and voltage. In general, the arcs were formed in three types of circuits—resistive, capacitive, and inductive—at either 75- or 7.5 kv. and with initial currents varying respectively from 8 to 60 and from 200 to 800 amperes peak. Connections for these circuits are shown in Fig. 3. Measurements were made by means of a magnetic oscillograph through the use of shunts for current measurements and resistance potentiometers of the water-hose type having a resistance of approximately 500,000 ohms for voltage measurements.

It is known that the resistance of a d-c. arc is not constant, but is dependent principally upon the arc current and length. Because of the variation in an alternating current over a cycle, it is to be expected that the arc resistance would vary over a cycle, and if the length of the arc changed from cycle to cycle, a change in the limits of this cyclic variation should be noted for succeeding cycles.

Curves of Fig. 4 show that through a cycle, the resistance varies over a wide range, being high for low values of current and low for high currents. The minimum arc resistance for the cycle near the point of extinction of the arc (28th cycle) is larger than the corresponding value for the cycle near the start. This difference arises from the lengthening of the arc and the decrease in current. The curves in Fig. 5 illustrate this change in instantaneous resistance with respect to time, and in general show an increase with the passage of time until the arc was extinguished. In the early stages of the arc the increase in resistance is caused by the lengthening of the arc; as the resistance increases it becomes a larger percentage of the circuit impedance and limits the arc current. The decrease in arc current still further increases the resistance, so that finally the arc is extinguished. The curves described are for a test made in a resistive circuit and are of the same nature as those for the capacitive and inductive circuits.

The question as to the phase relation between the arc current and arc voltage frequently has arisen. Although the oscillograms indicate that for every test the arc current and voltage have simultaneous zeros, the apparent power factor of the arc may not be unity if the variations of arc current and voltage are not sinusoidal. An analysis of the oscillograms for the tests in which the arc current varied from 8 to 60 amperes peak showed that the apparent power factor of the arc varied from unity near the start to 0.75 near the point of extinction. For the high-current tests (200-800 amperes peak) the apparent power factor was practically unity.

Changes in wave shape of the arc current and arc voltage are attributable to the variation in arc resistance over a cycle. Near the start of the arc the resistance is not of sufficient magnitude to affect the current, but the arc voltage is affected by the variation in resistance and tends to become a square wave. Near the point of extinction of the arc, where the resistance is greatly increased, the current is greatly decreased and distorted and the voltage approaches in magnitude and wave shape the open-circuit voltage.

The records obtained when the arc was formed in the three types of circuits (resistive, capacitive, and

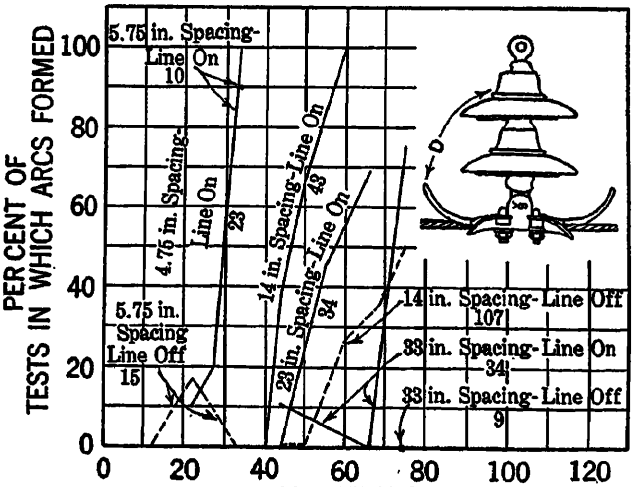


Fig. 2. Flashovers developing into power arcs

Tests made at various line voltages, with different electrode spacing D, and with and without the capacity effects of 35-mi. line. Numbers under spacing designation indicate the number of tests in each group

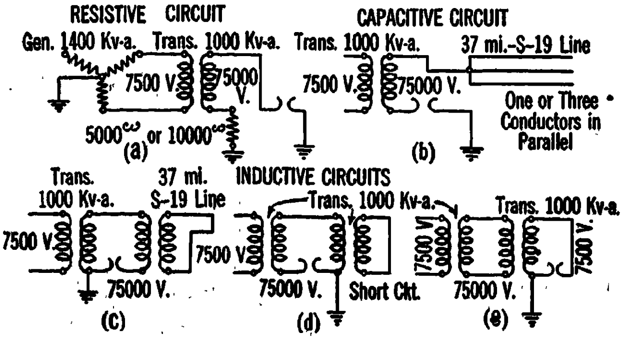


Fig. 3. Connections for tests of arc characteristics

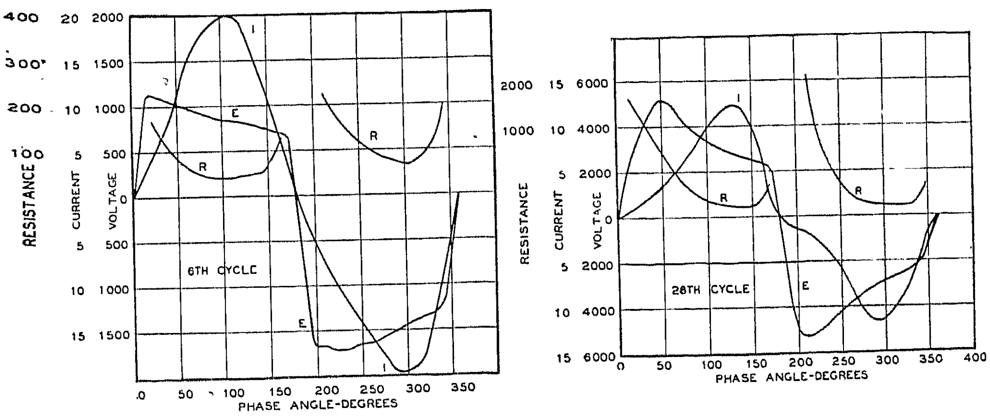


Fig. 4. Relations between arc voltage, current, and resistance for a cycle near the start of an arc and for a cycle near point of extinction

CORRECTION—In the "resistance" scaling of the center curve, "1000", should read "2000" and "2000" should read "3000"

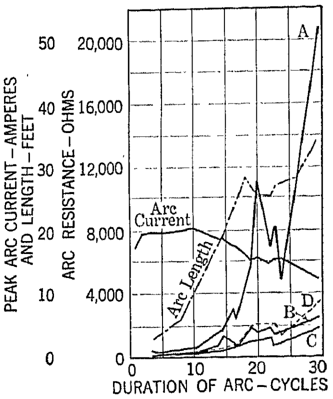


Fig. 5. Results of arc test in a resistive circuit

A—Instantaneous resistance for peak voltage
B—Instantaneous resistance for tail voltage
C—Instantaneous resistance for peak voltage
D—Ratio of peak current to peak voltage

inductive), indicate that only in the case of the capacitive circuit did the arc restrike following the first extinction at current zero. Although it was not possible to duplicate exactly the conditions of wind, wave shape, and current for these three types of circuits, apparently if arcs are formed under identical conditions in these three types of circuits, the capacitive arc will show the greatest tendency to persist because of its restriking after the first extinction. The explanation for the restriking of the capacitive arc lies in the fact that the charge trapped on the equivalent condenser in the circuit causes the voltage across the arc to rise to twice normal immediately following arc extinction.

A fairly accurate determination of the length of the arc was possible by combining the measurements from two motion picture cameras which were set up at right-angles to photograph the arc. Arc voltages which corresponded in time to the measurements of length were obtained from the oscillograms. It was found that if the peak voltage per foot of arc length were plotted against current, there was a very definite grouping of the points for currents above 100 amperes peak at 300 peak volts per foot of arc length. There was no definite grouping of the points for currents below 100 amperes peak.

Overvoltages Due to Arcing Grounds

Opinions vary rather widely as regards the maximum overvoltages which can be developed on an isolated-neutral transmission system at the time of an arcing ground, according to whether such opinions are based upon theoretical considerations, on laboratory tests, or upon limited operating data. From the tests on a part of the isolated-neutral transmission system of the Consumers Power Company information on the nature and magnitude of such overvoltages was sought.

In Fig. 6 is shown a schematic diagram of the 75-kv. three-phase system utilized. The transformers were connected either Δ/Δ or *Y*/*Y* with the low-voltage neutral grounded or isolated, and the length of line was varied up to 134 mi. Faults involving arcs to ground were produced on phase *M* conductor at different points on the line, which was open at the far ends. These faults were initiated in different ways and were made through both high- and low-external resistances. At the time of the fault the phase voltages to ground and the arc current were recorded on magnetic-type oscillographs as previously mentioned. Surge-voltage recorders were connected to the three phases at the generating end and at the open end of the transmission line to supplement oscillographic measurements of voltage.

The highest sound phase overvoltage recorded by the oscillographs in 64 arcing ground tests made on the isolated system was 2.8 times normal; the maximum surge-recorder measurement was 3.0 times normal. In every test the faulted phase voltage was less than the sound-phase voltage and in no case were the surge-recorder measurements more than 15 per cent higher than the corresponding oscillographic records. In a majority of the tests the maximum overvoltage occurred during the first cycle of the fault and was from 10 to 15 per cent higher on phase *B* which led the faulted phase voltage, than on lagging phase *T*. Average values of the highest overvoltages recorded during the fault for all the tests were 2.35 and 2.13 times normal for phases *B* and *T* respectively.

Oscillograms shown in Fig. 7 illustrate the nature of the transient changes at the time of a fault as they occurred in a large number of the tests. Both the striking and extinguishing of the arc take place according to normal (30-cycle) frequency. When the arc strikes, the faulted phase voltage is reduced to zero and a highly-damped standing wave follows the traveling wave set up on the faulted conductor. This standing wave is evidenced by oscillations in the wave of arc current and in the voltage wave recorded at the open end of the line (see oscillograms 82-A and 82-C). When the fault was at one end of a single-line system which was varied in length up to 94 mi., oscillograms showed that the frequency of these oscillations, called oscillatory frequency, corresponded to the free or natural period of oscillation of the line.

It may be seen in Test 82 of Fig. 7 that similar oscillations of low amplitude also are present in the voltage waves of the sound phases *B* and *T* at the striking of the arc. These small oscillations, however, do not occur at the highest crest of the voltage waves and add nothing to their maximum values. The overvoltage is essentially a fundamental-frequency phenomenon and is made up of (1) a change in impressed voltage from that of line-to-neutral to that of line-to-line without going through an oscillation of appreciable amplitude, (2) a d-c. transient which shifts the zero of the normal-frequency wave, and (3) in some cases a harmonic of lower order. Surge recorders testified that no transients of higher magnitude were present. In the case of an unstable arcing ground, such as that shown in Test 71, the current restruck from zero usually every half-cycle, when the voltage was equal to or less than its normal crest value, and resulted in no building up of overvoltages.

A high-resistance arcing ground fault such as an intermittent tree ground, even if it persists for some time, was found to limit the shift of the system neutral and hence to tend to limit the magnitude of overvoltages produced. The highest measured overvoltages, nearly three times normal, occurred for tests on the longest line (134 mi.) when the arc happened to strike just beyond the crest of the voltage wave. Changes in transformer connections, fault location, and method of starting the arc, did not materially change the nature or magnitude of the overvoltages.

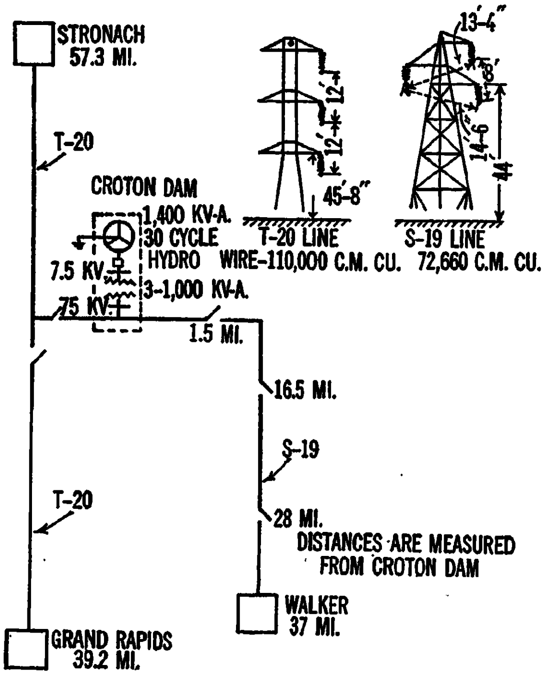


Fig. 6. Layout and configuration of test lines

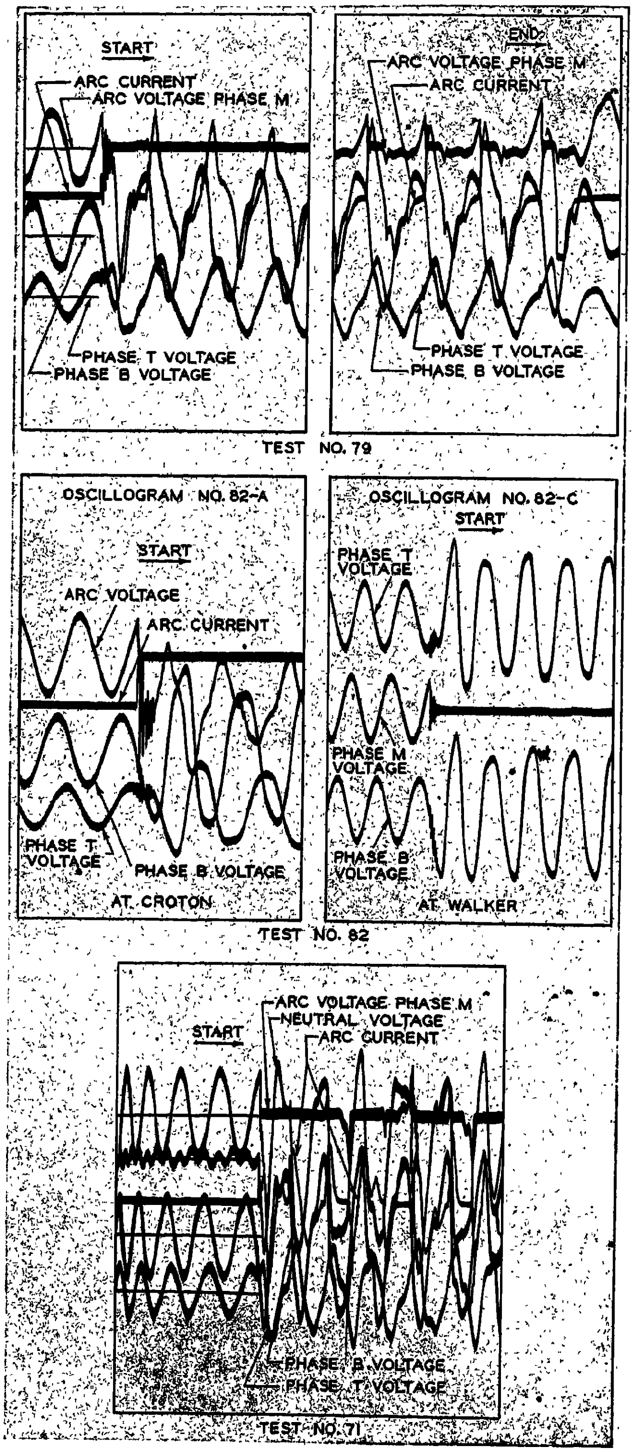


Fig. 7. Typical oscillograms resulting from arcing ground tests

Why Apply Science?

Most of the material things which man wishes to do can be done with certainty and repeated with assurance only through the application of scientific information. This is the fourth article of The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
H. E. HOWE
Editor, Industrial and Engineering Chemistry

HOW OTHER than through applied science could one discover why clean scab-free potatoes can be grown in some fields and not in others? It has been learned that the hydrogen-ion concentration of the soil is a determining factor, and simple means have been devised which enable an unscientific man to make the necessary tests, within limits, and choose soil of proper acidity to guarantee scab-free potatoes. A very small quantity of selenium in copper renders the copper less suitable for the transmission of electric impulses than if the copper were pure. Without science, how could such a small difference have been discovered? It is a further application of science to remove effectively the interfering selenium; and a still further utilization of science to find ways for employing the by-product selenium. It is another triumph of science that the use of selenium in certain types of glass has given us spectroscopic red glasses so necessary for signal lamps which must show red under all circumstances and to all eyes.

When, again through applied science, it became known how to use chlorine for bleaching textiles, it was not realized how quickly the chlorine will do its work under controlled conditions. Thanks again are due to science for learning these conditions and for determining what took place, with the result that under some circumstances thorough bleaching can be done in 45 seconds without detriment to the fiber.

There are uncounted examples of similar occurrences in industry, where a lack of uniformity in finished products would be immediately noticeable without the control possible only through applied science. Small differences in time, in temperature, in velocity, and in concentration, make for the difference between success and failure. It is science that determines what these limitations are, and again it is science that makes possible an adherence to a prescribed procedure which through experimentation has been found to give the desired results.

When it is remembered that, as Huxley said, science is organized common sense, the question "why apply science" answers itself. The life of a normal man is made up of little conquests with which he always is striving to achieve some objective. Most of these efforts involve materials, and it is with these same materials that science concerns itself.

The chances for having a thing do what one wishes are increased immeasurably as accurate knowledge is acquired, not only of what takes place, but of just how and why events occur as they do. When such details are known, happenings often can be controlled to a nicety. It is this control of natural processes that applied science makes possible; without such control there is loss, disappointment, and failure.

Fruitful application of science by no means is confined to industry. It has its most useful work today in the field of health and disease. There is perhaps no organism so delicately balanced as the human body; the mere difference of where an atom is placed in a molecule leads to so great a divergence in the characteristics of that molecule as profoundly to affect the human body. Adrenalin exists in two forms; one of these the mirror image of the other. One molecule may be said to be left-handed and the other right-handed. One has fifty times the potency of the other. Some of our best known germicides have been devised with a similar knowledge of the effect of small differences. Hexylresorcinol is much more useful than would be a compound with five or one with seven of these groups.

Other examples of comparatively small differences are found in carbon monoxide—a subtle, deadly poison—and carbon dioxide—a highly useful industrious gas. The difference is a single atom of oxygen. Mercury compounds show similar differences between the one use as a disinfectant and the other as a medicine. So long as such small differences are vastly important there is obvious need for the application of science, for without science these differences cannot be determined and the resulting information utilized.

Through its thousands of years, the race has learned much by bitter experience. However, even in the oldest industries, like bread making, tanning, and brick making, things have occurred beyond control until science stepped in to determine cause and effect, and to indicate conditions under which control may be maintained and success thereby assured. Most of the material things which man wishes to do can be done with certainty and repeated with assurance only when based upon scientific information. Progress in the oldest arts as well as in the newest can be measured accurately by the extent to which science is applied.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

Electric Analogs for Difficult Problems

When the mathematical solution of a problem is so difficult as to be impracticable it sometimes is possible to obtain the desired answer from the behavior of an analogous electric circuit. This article presents an analog of "coulomb friction," and demonstrates the application of this analog to the previously unsolved problem of the torsional-vibration damper.

By
H. H. SKILLING
Associate A. I. E. E.

*Stanford University
California

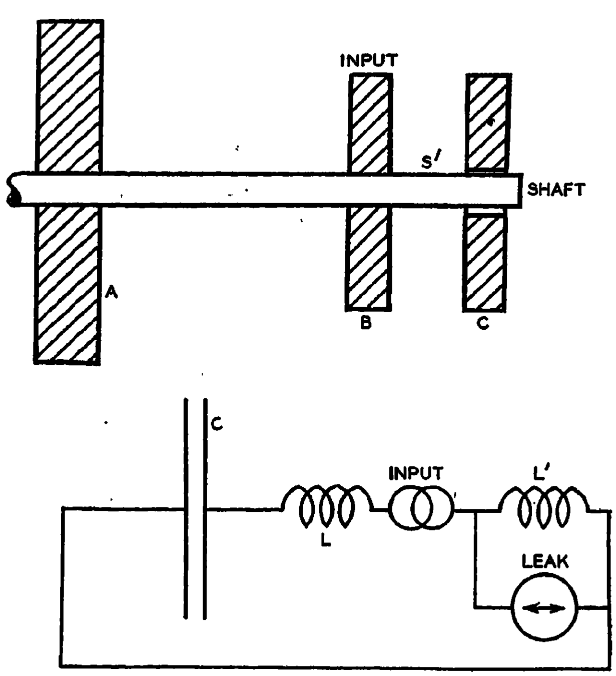


Fig. 1. (Above) mechanical system schematically representing the Diesel engine; (below) the electric analog of this mechanical system

SOLUTION of the equation of motion for the torsional-vibration damper represents one of the mathematical problems which is extremely difficult to solve. Almost endless complications are involved on account of the peculiar combination of vibratory motion and friction which the problem contains. An approximate solution can be arrived at by introducing several assumptions, but this is not entirely satisfactory; in the more intricate cases, approximate solutions are of no value at all. In order to predict the effectiveness of new designs, mechanical models sometimes are built and tested. Difficulty often is experienced, however, in the construction of these models, and in addition, the results obtained have been found to be somewhat uncertain.

In this article is proposed a method of solution wherein electric analogs are set up for the various types of mechanical motion involved. An electric circuit can then be set up with constants analogous to the mechanical characteristics of the apparatus being studied. The principal advantage in treating the problem in this manner is in dealing with a system easily put together and altered, and with quantities easily metered. Although the analogous method in general is not new, difficulty has been experienced previously in representing mechanical friction electrically. In the present investigation this obstacle has been overcome by the use of gaseous conduction tubes.

The torsional-vibration damper is in effect a flywheel that fits loosely on a shaft. A common application is on the crank-shaft of a Diesel engine, where there is danger of torsional stress in the shaft becoming extremely large because the natural frequency of oscillation of the shaft may be the same as the firing frequency of the cylinders. The damper flywheel is placed on the shaft at the point where torsional vibration is greatest; it is not keyed fast but turns with the shaft because of the friction between the two. When rapid torsional vibration of the shaft exists, the friction force is not great enough to accelerate the flywheel as rapidly as the shaft; hence the shaft slips within the flywheel and in so doing dissipates sufficient energy to prevent resonant oscillation of the shaft. In actual design, the damper although simple is not so elementary as this account has indicated. A detailed description may be found in a paper by Den Hartog and Ormondroyd (*A. S. M. E. Trans.*, Vol. APM-52-13, p. 133) which also treats its action by an approximate mathematical solution.

With ordinary dry friction—so-called "coulomb friction"—which is involved in the torsional-vibration damper, the frictional force depends upon the nature of the rubbing surfaces; also upon the force holding them together, but not upon velocity. An electric analog for this application must therefore produce a constant voltage drop, variable at will but independent of the amount of current flowing.

A mechanical system which is the practical equivalent of a Diesel engine may be seen in Fig. 1. The main flywheel is shown at A; moment of inertia of the pistons, cranks, and other moving parts is represented by another flywheel B; the damper flywheel which fits

---

*Written especially for ELECTRICAL ENGINEERING and the A. I. E. E. TRANSACTIONS based upon research work carried on by the author at Massachusetts Institute of Technology, during 1929-'30. *Not published in pamphlet form.*

loosely on the shaft is shown at *C*. Input torque from the cylinders, which may be considered as a steady torque with a superposed alternating torque, enters the system at the pistons. Any load on the engine will be applied to the left of the main flywheel.

Table I—Mechanical-Electrical Analogies

Mechanical quantity	Electrical quantity
Torque	Voltage
Velocity (angular)	Current
Displacement (angular)	Charge
Moment of inertia	Inductance
Elastance (torsional)	Elastance
Mechanical hysteresis	Resistance

The electrical analogy to this mechanical arrangement is shown also in Fig. 1 where, with the exception of friction between the shaft and the damper flywheel, the electrical quantities used are as shown in Table I. Analogous to the shaft is condenser *C*; analogous to the piston flywheel *B* is inductance *L*. These cooperate to form the oscillating system, since the main flywheel s so large that for the present it can be considered infinite and therefore impassable by any vibrations. The damper flywheel *C* is represented by the inductance *L*, but because of its looseness on the shaft a shunt must be connected around the inductance to make the analogy complete. In this shunt is the apparatus which, to be analogous to friction of the flywheel on the shaft, must prevent current from flowing until a certain voltage is reached, and then permit current to pass without any further increase of voltage.

The peculiar property of constant voltage drop is possessed by a mercury arc; it is also characteristic of glow discharge under special conditions. For this investigation raytheon gaseous conduction tubes were employed. Two tubes were used, one to pass current in each direction; the voltage drop in the tubes as they were connected in this case was 85 volts independent of current. In series with each tube was a source of potential which either added to or subtracted from the 85-volt tube drop depending upon other conditions. For the input to the circuit an alternator was used the speed and voltage of which could be varied over an extremely wide range; its resistance, together with that of the rest of the system, was small. For mechanical hysteresis losses in the elastic parts, and for any viscous friction that may exist, resistance is sufficiently analogous to permit its use.

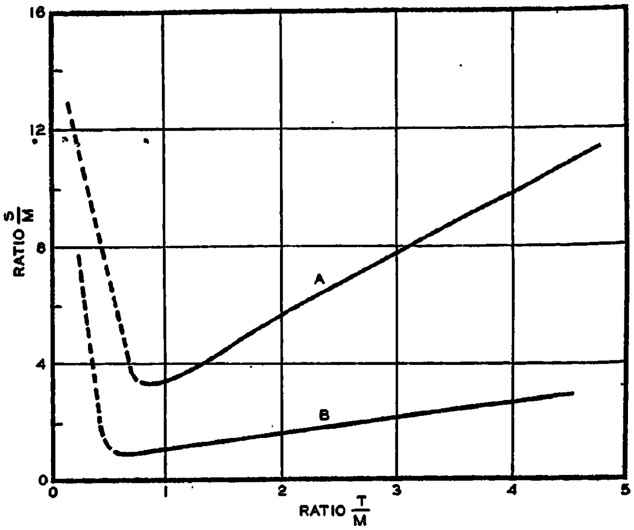


Fig. 2. Performance curves for the torsional-vibration damper as determined by electrical anal gy. (A) With rigid damper shaft, (B) with lastic damper shaft

The validity of the complete analogy may be seen from the differential equations of the two systems which are adapted from Den Hartog. For the mechanical system,

$$I \frac{d^2 \alpha}{d t^2} + I' \frac{d^2 \alpha}{d t^2} + k \alpha = M \sin \omega t$$

when the damper flywheel is not slipping, and

$$I \frac{d^2 \alpha}{d t^2} + k \alpha \pm T = M \sin \omega t$$

when this flywheel is slipping.

I = moment of inertia of system being damped
I' = moment of inertia of damper flywheel
k = elastance of shaft
α = flywheel displacement from neutral
$M \sin \omega t$ = input torque as a function of time

The analogous electrical equations, when the shunt is not working and when it is, are respectively,

$$L \frac{d^2 q}{d t^2} + L' \frac{d^2 q}{d t^2} + \frac{1}{C} q = e \sin \omega t$$

$$L \frac{d^2 q}{d t^2} + \frac{1}{C} q \pm v = e \sin \omega t$$

All terms are well known except *v*, the voltage drop in the leak, which is added or subtracted depending upon the direction of the current. The analogy of corresponding terms, displacement, and charge, for example, may be seen to agree with Table I.

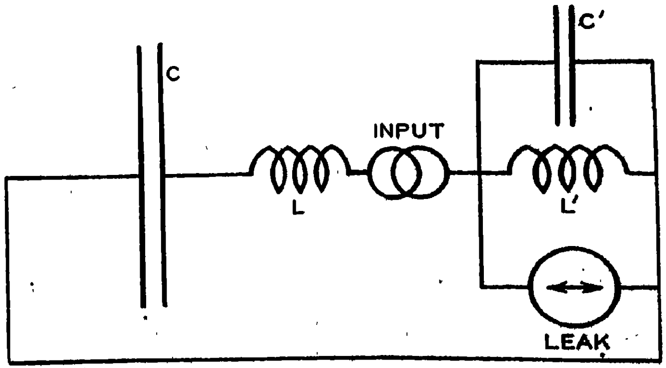


Fig. 3. Electric anal g f the torsional-vibration damper with elastic damper shaft. Compar Fig. 1

The purpose of making a detailed study of damper performance, whether by mathematics, model, or analogy, is to determine whether a particular damper is so proportioned as to prevent dangerous stresses in the shaft. Momentary stresses in a shaft are exceedingly difficult to measure, but the analogous voltages across the condenser in the electric circuit may be read quite easily on a crest-reading voltmeter; thus for any given combination of quantities and dimensions an indication of maximum stress is obtained immediately by simply reading that meter.

The crest voltage of condenser C (Fig. 1) is analogous to the maximum torque in the shaft and will be designated by S; analogous to the torque required to slip the shaft inside the damper flywheel, is the voltage drop in the leak which will be denoted by T. Results of a study by such analogy may be plotted showing S as a function of T, where curves similar to those of Fig. 2 will be obtained. If the value of S at the lowest point of the curve represents a safe stress, the damper is large enough to be useful; the value of T corresponding to this minimum value of S gives the optimum adjustment for tightness of the damper flywheel.

To avoid changing back and forth from mechanical to electrical units, it is well to avoid absolute values of quantities. Relative values need not be so transformed. Let M be the amplitude of the alternating input torque; instead of plotting S as a function of T, S/M may be plotted as a function of T/M. This scheme involves neither volts nor foot-pounds but only ratios, the ratio of voltage to voltage being of course numerically equal to the analogous ratio of torque to torque. The scale of the electrical model is equally unrestricted; only the proper ratios between parts need be specified. The frequency of the input voltage is of course the frequency causing the most severe stress; in the simple mechanical system the crucial stress will occur when the frequency of firing is the same as the natural frequency of the vibrating system.

As a typical example, assume a damper with moment of inertia of the damper flywheel equal to the moment of inertia of the system being damped. In the analog any convenient capacitance and inductance may be used to represent C and L (Fig. 1), but they must be resonant at some frequency attainable by the alternator used for *input*. The inductance L' equal to L is then added, and the vacuum-tube leak is connected across L'. The input voltage is adjusted to any convenient value, and the voltage drop in the leak circuit made comparatively large (for instance, 15 volts input and 85 volts drop in the leak). Now, as the frequency of the input voltage is varied, the crest voltage across condenser C will rise to a maximum and then decline. The maximum value of this voltage (in this particular case about 208 volts) is analogous to the maximum torque in the engine shaft. Dividing this by the maximum value of the input voltage, (about 21.2 volts) and the result S/M is about 9.8; divide the 85-volt drop also by 21.2 and the quotient, which is 4, is the value of T/M. By varying the leak and input voltages, enough points can be determined to give curve A of Fig. 2. This curve gives the whole story of the operation for this particular damper. Moreover, it gives the entire story of operation for all dampers having the same moment of inertia as has the system being damped. In present practise, however, a damper has from one-fifth to one-tenth the amount of inertia of the system being damped, and S/M is proportionately larger.

So far, the damper has been considered as being applied to the simplest possible vibrating system. This simple system may be solved mathematically, although with some difficulty if approximations are avoided. Accordingly, this case was used as a general check on the method, and the results were compared with Den Hartog's computed values; agreement was so close as to be within the limits of experimental error.

With the more complicated systems, however, solution by analogy is of far greater value. When the elastance of that part of the shaft labelled S' (Fig. 1) is considered, a mathematical solution is out of the question; in the analog a condenser of the proper size is simply shunted around L', and the solution is as simple as before. The study of this circuit disclosed an interesting and important relationship that previously was not recognized. As it is a typical analog, it will be used as a further example of the application of the method.

The circuit used with C' representing the elastance of the damper-shaft is shown in Fig. 3. The elastance of condenser C' must bear the same proportion to condenser C as elastance of the damper-shaft does to the main shaft. Now as the input frequency is varied, the voltage measured across C no longer has one maximum, but three. The reason for this is apparent from the diagram, since there are now two resonant parts of the circuit, consisting of (1) C and L and (2) C' and L'. At some definite frequency the reactance through C and L in series is zero; at two additional frequencies the reactance of the complete circuit is zero. However, if the natural frequency of C' and L' is the same as that for C and L, when the reactance through C and L is zero, the reactance through C' and L' is infinite; thus the circuit current under these conditions is small and one maximum eliminated. The other two maxima, one falling at a higher and one at a lower frequency, must be prevented from becoming serious by the action of the leak.

Experiments with this second analog showed that the damper is much more effective with an elastic damper-shaft than it is with a rigid shaft as in the first case. When the damper flywheel has one-fifth the moment of inertia of the system being damped, and when the damper-shaft is one-fifth as stiff as the main shaft, the analog method gives results as shown in curve B, Fig. 2. To make due allowance for the light weight of the damper, all ordinates have been multiplied by the ratio of moments of inertia (one-fifth); this makes the curves comparable to those of Den Hartog and Ormondroyd if a factor of $1/\pi$ is introduced into the vertical scale.

Since the primary purpose of this article is to point out the merits of the electrical means of solution, no particular attention is given to the mechanical merits of this new design of damper. Certain relationships were discovered by study of the analog, however, which seem worthy of mention. The "elastic damper-shaft" is not in the nature of a spring, for a shaft one-fifth to one-tenth as rigid as the main shaft of a Diesel engine is needed. The torque on the damper-shaft never can exceed T, the slip torque of the damper, and the shaft may be designed accordingly. The smaller the damper, the more effective will be a proper damper-shaft in improving its performance.

In conclusion, the principal advantages to be gained by the use of the electric analog are that (1) it shows the extent to which an approximate mathematical solution may be trusted, and (2) it offers a new method of approach to designers of dampers and other frictional devices. It is particularly useful in the study of new designs and at present there appears no limit to the possible applications of the method.

Power Equipment at KDKA's New Station

By
R. L. DAVIS
Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., Chicopee Falls, Mass.

Power for the two new high-power radio transmitters housed in KDKA's new quarters is obtained from a special 1,500-kva. outdoor substation. Included in the power equipment is a twelve-phase, 900-kw., 30-kv., mercury-cathode tube rectifier, the largest of its type yet built for radio.

THE NEW KDKA radio station at Saxonburg, Pa., has been designed not only for high-power broadcasting but also for experimental work dealing with the development of super-power transmitters. Two complete and independent high-power transmitters are involved, both being housed in the same building. One of these normally is operated at 980 kc. using the familiar signature KDKA, while the other is planned for higher frequency work. A station of this nature quite obviously required equipment considerably larger than that found in any ordinary broadcasting station. This is especially true of the power supply apparatus, among which the larger of the two main rectifiers is the largest high voltage unit ever constructed for such use.

Power is obtained from a 1,500-kva. outdoor substation about 700 ft. distant from the station building. This substation is fed from a 25-kv. loop circuit with relays and breakers so arranged that in case of trouble any faulty portion of the loop will be disconnected automatically without service interruptions on other portions. From the low voltage side of the transformer bank, power is carried to the station building over two three-phase 2.5-kv. armored cables laid directly in the ground.

MAIN RECTIFIERS

Both main rectifiers are of the polyphase mercury cathode type and operate directly from the 2.3-kv. three-phase supply. The larger rectifier has a rating of 900 kw. at 30 kv., and employs six 190-kva. single-phase transformers to provide the proper voltage and phase relations for twelve-phase rectification. (See Fig. 1.) Special connections are employed on the supply side of these transformers, since a Y-connection with floating neutral is undesirable for rectifier service.

Three of the transformers are connected in delta and the other three are carried across this delta from each apex to the midpoint of the opposite side, a tapped primary winding being used to give the required voltage relations. All six transformers are provided with two separate high voltage windings; these are connected to form four Y's, each of which is connected to one multi-anode mercury cathode rectifier. The d-c. outputs of the four tubes are connected in series so that while rectification takes place in four three-phase units, the result is the same as though a single high voltage multi-anode tube of twelve phases were employed. Connecting the outputs of the four tubes in series in this manner also requires only a moderate

---

Based upon "Power Equipment at New KDKA Station" (N . 31-67) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

inverse peak voltage per tube in spite of the unusually high d-c. voltage developed.

The smaller, or 450-kw. 20-kv. rectifier, is similar to the larger one except that only three single-phase transformers are employed thus providing for six-phase rather than twelve-phase rectification. In both cases untuned filter circuits consisting of large iron-cored reactors and banks of high voltage condensers are employed to smooth the rectifier output.

Adjustment of the d-c. voltages developed by the rectifiers is accomplished by means of three-phase induction regulators designed to operate over a range of 100 per cent above and below line potential. With this arrangement the applied a-c. potential thus may be varied from 0 to 4.6 kv. Both regulators are motor operated and are remotely controlled from the operating room. The output of both rectifiers is controlled by air-break contactors similar to those used in mine hoist control, and which operate directly in the 2.3-kv. supply circuit. Both a-c. and d-c. overload relays are provided to shut down the equipment in the event of trouble necessitating the removal of plate voltage. For safety to operators the contactor control circuits are interlocked through switches on doors giving access to high voltage circuits. An oil circuit breaker manually operated from the main switchboard also is provided for each rectifier.

MERCURY CATHODE TUBES

Tubes used in the main rectifier are of the glass envelope mercury cathode type (see Fig. 2) and are somewhat similar to ones formerly used for operating d-c. series arc light circuits. The tubes are fully immersed in oil, each being housed in a separate tank and mounted in a cradle by means of which it can be removed readily. (See Fig. 3.) All necessary connections are made when the cradle slides into place, thus permitting tube changes to be made conveniently. For interchangeability, tubes of the same rating are used in both main rectifiers.

In addition to the three main anodes, the tubes are equipped with two small sustaining arc anodes, and one starting mercury anode. Automatic tilting mechanisms controlled from a push-button station are provided for starting the sustaining arcs. This mechanism functions in from one to two seconds, after which full operating plate potential may be applied immediately. Very little energy, about 120 watts per tube, is required to operate the sustaining arcs. This is small compared to the filament heating requirements of a filament type tube rectifier for furnishing the same power output. While not commonly employed for radio power apparatus, nevertheless mercury-cathode rectifier tubes have desirable characteristics particularly in installations such as these where the use of filament tubes would be prohibitive on account of the number required.

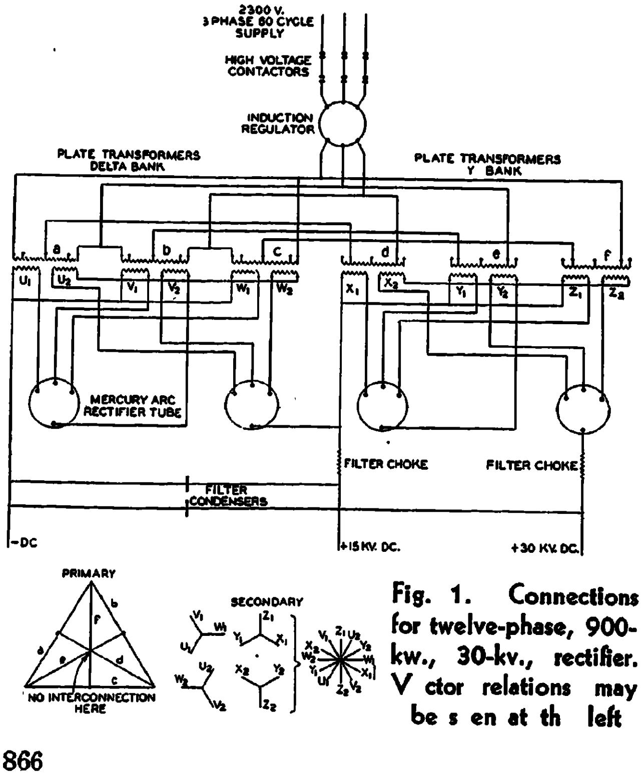


Fig. 1. Connections for twelve-phase, 900-kw., 30-kv., rectifier. Vector relations may be seen at the left

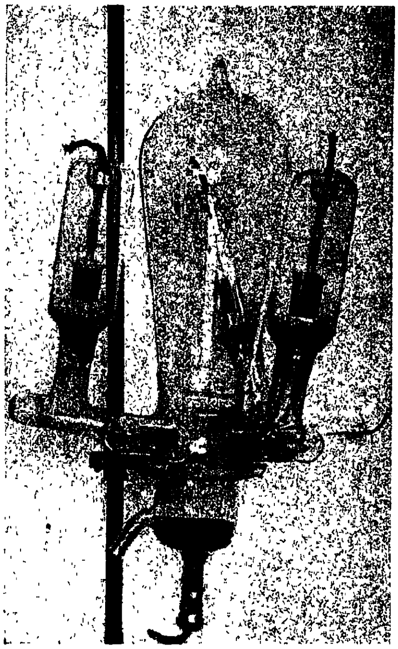


Fig. 2. High voltage mercury-cathode rectifier tube

FILAMENT HEATING GENERATORS

In all but very small telephone transmitters, direct current is required for heating vacuum tube filaments. To meet the requirements of both transmitters, a total of six motor-generators were installed, three normally being assigned to the 980-kc. set and two to the higher frequency outfit, leaving one in reserve. A view of one of these generators is shown in Fig. 4. Each generator is rated conservatively at 1,000 amperes 40 volts d-c., and is driven by a 75-hp. line-start motor operating directly from the 2.3-kv. station supply. To reduce commutator noise to a sufficiently low value so that no filter is required, the design of these generators include special features such as large air gaps, skewed slots and a large number of commutator segments. As an added refinement each unit is mounted on a concrete base and the whole assembly supported on a cork pad to minimize vibration.

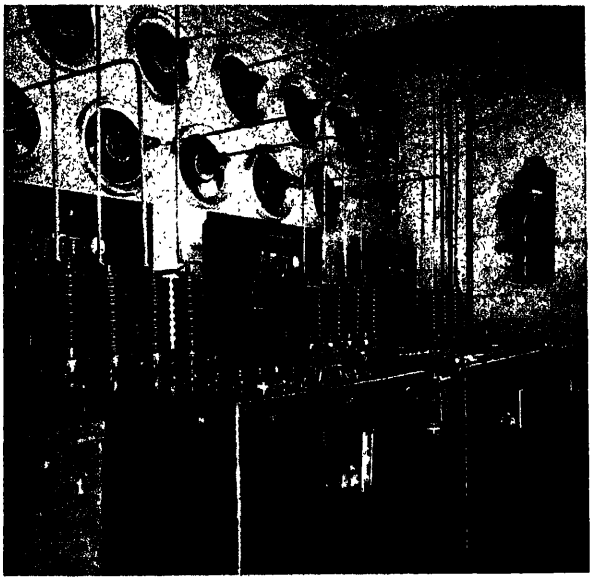


Fig. 3. Tanks housing main rectifier tubes

Interlocks between the tube cooling-water relays and the filament generator field circuit provide low-water protection. A special starting resistance in the field circuit also is interlocked with the filament excitation control which prevents a damaging current rush when voltage first is applied to the tube filaments since these possess only about ten per cent of normal operating resistance when cold.

Besides the six filament-heating motor-generator units, four 10-kw. 3-kv. d-c. generators are employed to furnish plate circuit energy for the smaller intermediate amplifiers and also to provide grid bias voltages. These generators have two 1,500-volt commutators connected in series, and are provided with filters to reduce commutator ripple.

All four generators have one terminal permanently connected to the filament bus or ground circuit. This is possible since the change of polarity necessary when changing from plate to grid service can be accomplished by simply reversing the excitation. To simplify interchange of connections, a special bar and plug board without cables is used. On the rear of this board are mounted vertical and horizontal interconnecting bars to which the transmitter circuits and generator terminals are connected. Any desired combination of connections may be effected simply by plugging through the front of the board to the connecting bars. The dead front construction virtually eliminates live plug danger.

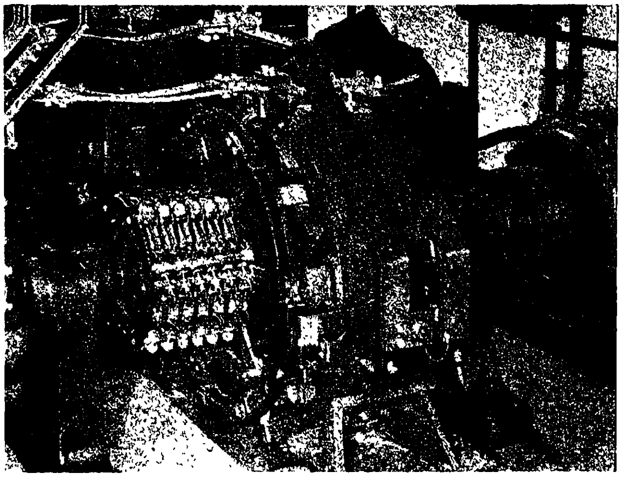


Fig. 4. One of the six 1,000-ampere 40-v lt generators used for tube filament heating purposes

CONTROL EQUIPMENT

The entire control scheme for the power equipment has been arranged in so far as possible so that in the normal course of operation the operator need not leave his position in the main transmitter room. Relays and interlocking mechanisms are provided so that none but the proper sequence of operation is possible. Signal lights adjacent to push-buttons indicate the state of circuit relays and response of contactors being controlled. Suitable meters inform the operator of the operating conditions of all important transmitter power circuits.

All control circuits and meter leads from the outdoor substation to the transmitter building are installed underground to prevent possible high frequency effects. To avoid an otherwise unnecessary 110-volt battery and resulting high voltage drop between the transmitter room and substation, special 400-volt coils were used in the circuit breakers thus permitting their operation from the station "B" battery.

Adequate control of the various intermediate amplifier stages requires the opening and closing under load of 3-kv. d-c. circuits. For this purpose a special 2-ampere contactor was developed having two air breaks in series both equipped with magnetic arc blowouts. The contactor employs a special mechanism to obtain rapid contact travel and wide openings.

OTHER APPARATUS

Besides the major power units which have been described many conventional pieces of equipment are used such as exciters, tube-cooling-water pumps, blowers, battery chargers, and station service transformers for the small power units, lights, and heating. For simplicity of control and convenience in starting, all motors including the 75-hp. units which drive the filament generators, are of the line-start type.

Although one battery will suffice for plate or "B" service, since by the employment of suitable filters it can be charged readily while in use, two filament batteries are advisable because of the difficulty of eliminating hum from heavy-current charging apparatus. Each of these should be capable of handling the entire load for one day. Accordingly, two six-cell, 1,600-ampere-hour storage batteries are furnished for the filament supply of the audio and synchronizing equipment in addition to the previously mentioned 400-volt "B" battery used for plate supply for small tubes. These large batteries also supply essential indicating lamps for the substation circuit breaker control, which require continuous illumination in the event of power failure.

In many broadcasting stations the tube cooling water is cooled in turn by a system of radiators and blowers. At the KDKA station site an opportunity to reduce the investment in cooling equipment was presented by the natural high level of ground water. Accordingly, a small pond was excavated from which sufficient water is obtained for cooling the tube cooling water by means of heat interchangers.

While commercial broadcasting stations as yet do not require equipment as large as that installed in KDKA's new plant, actual construction and use of such apparatus is necessary before the development of commercial high-power stations can be carried out. It is hoped that data can be obtained which will be of value not only in the specialized field of radio engineering but also to electrical science as a whole.

Reactance of Lines With Ground Return

By
J. E. CLEM
Member A.I.E.E.

General Electric Co.,
Schenectady, New York

Charts have been prepared which make possible the fairly accurate determination of the resistance and reactance of the earth return circuit. These values, together with the usual line and ground wire self-inductances, may be inserted in a simple formula to determine the positive or zero-phase-sequence impedance of the complete circuit.

AN ACCURATE knowledge of the zero-phase-sequence impedance of transmission lines is necessary for the successful analysis of current flow during fault conditions. This factor is becoming increasingly important, because the faults which must be considered generally are those involving grounds; the use of the symmetrical-component method greatly simplifies their calculation. The constant increase in size of electric power systems, and in demand for reliability in service, necessitates an application of suitable relays determined largely upon knowledge of current flow during fault conditions. Therefore it is becoming increasingly important that the value of zero-phase-sequence reactance be accurately known. The zero-phase-sequence reactance of transmission lines is the reactance of the three line conductors in parallel with a ground return. The two main problems in the determination of this quantity are the mathematical analysis of the circuit and the determination of the ground return impedance.

Equations have been developed for the impedance of a circuit consisting of any number of line wires in parallel and a return path through ground alone or through ground and any number of ground wires in parallel. The application of these equations, however, is contingent upon a knowledge of the impedance of a single conductor with ground return. The impedance of such a circuit varies with several factors, chief of which is the distribution of the current in the return path below the surface of the earth. While this is largely dependent upon soil conditions, it obviously will vary with the locality and terrain. Hence, field tests have been made to obtain experimental data to use in predicting ground impedance, and to check the theoretical analysis.

From "Reactance of Transmission Lines with Ground Return" (No. 31-64) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

CIRCUIT ANALYSIS

The analysis of the circuit is very simple although it involves such factors as the self-inductance of the earth path and the mutual inductance between a wire and the earth, which usually have been considered as fictitious quantities. By proper manipulation, however, the equations can be made to take on a real and definite form. For the analysis as given here it is assumed that the line wires are transposed so that the same current flows in each of the conductors. It is assumed also that the spread of the current in the earth is such that its mutual effect on all the line conductors or ground wires is the same within the usual horizontal spread of line conductors. Tests show that the error from this source is small.

Consider the circuit shown in Fig. 1. The impedance of such a circuit in this analysis is defined as the ratio of the applied voltage, E_{mn}, to the total current I. The current flows from the generator out along the line wires to the point of fault and back to the generator through the ground and ground wires in parallel. The effect of the current in the ground wire is simulated by a pseudo conductor imbedded in the earth and assumed to have a self-inductance of its own and a mutual reactance with the real conductors of the circuit. The depth of this assumed conductor below the surface of the earth, and its effective diameter, are not of interest for this analysis.

Starting from the generator, the voltage of the circuit is made up of the voltage drop from the generator through the ground to the point of fault and the voltage drop along one of the line conductors from the point of fault back to the generator. The voltage drop in any conductor of a circuit is made up of the voltage drop produced by the current in the conductor and its own self-inductance, and the voltage drop induced in the conductor by the current in other conductors through the mutual inductance. This may be written in the form of an equation; unfortunately, however, such an equation would contain the self-inductance involving the earth. This usually is said to be impossible of separate determination. If this self-inductance is combined with the mutual inductance between the earth and the line wire, or ground wire, reactance quantities are obtained which are real and which can be determined by measurement.

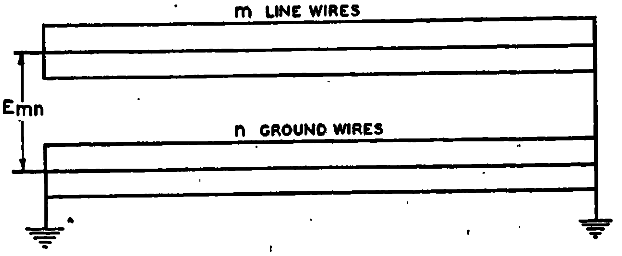


Fig. 1. Fundamental circuit of line wires, ground wires, and ground

of the conductor itself and does not depend in any way upon other conductors in the neighborhood. For mutual inductance another factor of course is required. If the current returns through the other conductor, the voltage drop in the first conductor is $I\ (L - M)$. This quantity $(L - M)$ usually is known as reactance. It can be determined by test or calculations either for a one-way conductor of a circuit alone or for both in series.

By the proper combination of resistances, reactances, and mutual inductances, the following expression for total circuit impedance can be developed:

$$\frac{E_{mn}}{I} = Z_{mn} = Z_{wg} - \frac{I_o}{I} M_{ow} - \frac{m-1}{2m} Z_{ww} \qquad (1)$$

where

$$M_{ow} = \frac{Z_{wg} + Z_{og} - Z_{ow}}{2} \qquad (2)$$

and

E_{mn} = circuit voltage
I = current as indicated by subscripts. Lack of subscript indicates total current
Z = impedance as indicated by subscripts
M = mutual impedance, as indicated by subscripts
m = number of line wires
n = number of ground wires
g = subscript indicating ground
o = subscript indicating ground wire
w = subscript indicating line wire.

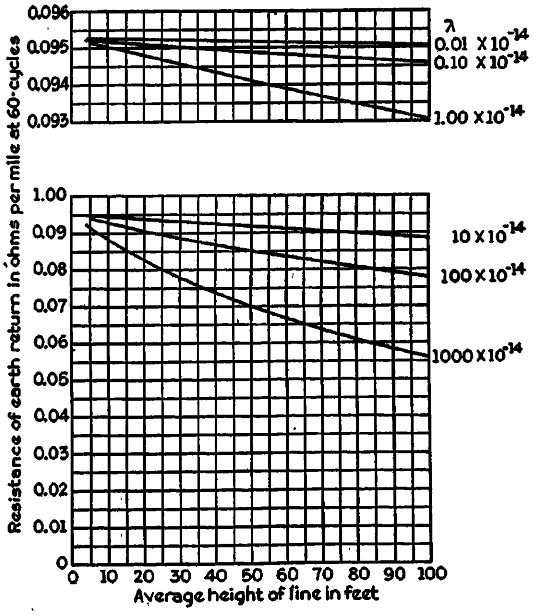


Fig. 2. Resistance of the return path through the earth for different values of earth conductivity λ and height of line

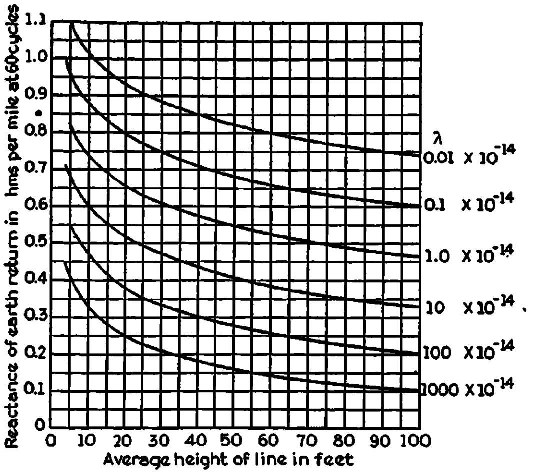


Fig. 3. Reactance of the return path through the earth for different values of earth conductivity λ and height of line

The zero-phase-sequence impedance enters into the calculations of ground fault currents as a quantity which operates on the zero-phase-sequence current. This current is equal and in the same direction in all three line wires and is one-third of the ground fault current. Accordingly the zero-phase-sequence impedance of a transmission line is the quantity obtained by multiplying by three the value of impedance given in equation (1).

The equations for the current in the ground wires may be developed from the fact that the over-all voltage drop from the generator through the ground to the point of fault outside the earth, and along the ground wire to the point of fault must be equal. The resulting equation is

$$\frac{I_o}{I} = \frac{M_{ow}}{Z_{og} - \frac{n-1}{2n} Z_{oo}} \qquad (3)$$

To check the analysis field tests were made on four power systems facilitated by the use of a test wire parallel to the transmission circuit. These tests were made both with and without a ground wire and definitely indicate that the analysis is correct within a few per cent in all cases.

GROUND RETURN IMPEDANCE

The successful application of the mathematical analysis depends upon a predetermination of the ground return impedance. The main problem in the calculation of ground fault current and the division of the return current between the ground wires and ground is the predetermination of the impedance of the fundamental circuit consisting of the conductor with ground return.

For many years it was customary to consider the earth as a perfectly conducting plane. All the reactance was assigned to the conductor and the corresponding distance to the "neutral plane" was calculated. This gave effective conductor heights up to several thousand feet and a wide variation was found, so that no good method of predicting the impedance of the circuit could be built up.

The calculation of the impedance of the fundamental circuit made up of a conductor with ground return requires a study of the distribution of the current in the ground. A solution to this problem has been given by Carson in the *Bell System Technical Journal,* October 1926. With some modification the expression developed by Carson states that the total impedance of the circuit equals the resistance of the conductor plus the reactance of the conductor plus the impedance of the ground return. The reactance of the conductor is calculated as if the return conductor were below the surface of the ground a distance equal to the height of the conductor. In other words, it is the one-way reactance of the conductor with image return.

The impedance of the earth Z_g in the solution worked out by Carson depends upon the conductivity of the earth, the distance from a conductor to its image, and the frequency. From these variables and an additional

Table I—Test Values of Earth Conductivity

System or location	Reactance per mile		$\lambda \times 10^{-14}$
	Line	Earth	
P P & L	0.976	0.499	1.8
Consumers	1.069	0.321	42.7
Appalachian	0.970	0.434	3.3
Alabama	0.984	0.724	0.065
Cross Keys[1]			42
Glens Falls[1]			175
Massilon[1]			36
Cross Keys[2]			33
U. S.–Canada[3]			200 to 0.1
Vicinity Chicago[4]			9
Eastern Texas			125
West Virginia			55
Penn.—Maryland			0.5
New Jersey			9
New Jersey			30
Ohio			100
Utah			30
Minn			10
Indiana			30
Maryland			8
New York			15
Penn			1
Penn			10
Wisconsin			1
Tenn			1
Ga			0.3
Ill			50
Near Ottawa			5
Oklahoma			100
Alabama			5

1. Gilkeson and Bowen, A. I. E. E. TRANS., Oct. 1930, p. 1375.
2. E. P. Peck, Discussion, A. I. E. E. TRANS., Oct. 1930, p. 1379.
3. E. B. King, Discussion, A. I. E. E. TRANS., Oct. 1930, p. 1379. Values given are average of more than 30 tests and the statement is made that 75 per cent of the values of λ are in the range from 100 × 10^{-14} to 10 × 10^{-14}.
4. This and all the values following given through the courtesy of the joint D & R Committee sponsored by the A. T. & T. and NELA.

factor dependent upon the configuration of the conductors, two values may be obtained from previously prepared tables which give directly the value of the impedance of the earth. A sufficiently accurate result for ordinary purposes, however, may be obtained from the curves of Figs. 2 and 3, based on Carson's formula with some simplification.

To apply this method it is necessary to have some idea of the values of the conductivity of the earth, since that is the final variable. Test values of earth conductivity are given in Table I. They apply to specific tests, but may be used to estimate the value of earth conductivity for other regions. The striking thing about this data is the wide variation in earth conductivity for a relatively small variation in ohms per mile impedance.

Fortunately, it is not necessary to know the value of earth conductivity with any great degree of accuracy to determine within a reasonable degree of accuracy the impedance of a transmission line with earth return. An error of 1,000 per cent, ten to one, in the value of earth conductivity will give about 30 per cent error in the earth reactance, which reduces to about 13 per cent error in the reactance of the circuit of conductor with ground return. The relative error dwindles further when the line reactance is in series with transformer and generator reactance.

In solving any particular problem it is necessary only to select the most probable values of earth conductivity for the line in question and then read off the unit values for ground resistance and reactance for the proper value of average height of line. These values in the proper relation to the test or calculated values of conductor impedance then can be inserted in equation (1) to give the impedance of the total circuit. The value of impedance for the various conductor groupings can, of course, be obtained by the customary method.

For values of earth conductivity at frequencies other than 60 cycles, the curves of Figs. 2 and 3 can be applied using an effective height equal to the square-root of the ratio of the actual frequency to 60 cycles. The values read from the curves also must be changed from 60 cycles to the actual frequency by direct proportion.

Circle Diagrams for Short Lines

When once constructed, circle diagrams furnish the means by which many phases of transmission-line performance can be checked quite readily. A method is given here by which the center loci are determined for a large number of short-lines where capacitance may be neglected.

By
T. D. OWENS
Member A. I. E. E.

Case School of Applied Science, Cleveland, Ohio

CIRCLE DIAGRAMS for transmission lines serve two general purposes: they furnish a check on long and laborious calculations, and in addition present a visual picture of the problem which mathematical solutions fail to give. Furthermore, when once constructed, such diagrams yield solutions for a large number of possible operating conditions with very little added work. For problems such as the determination of synchronous condenser capacity required for constant-voltage operation and stability, this feature is extremely valuable.

In the following discussion the visual conception and interpretation of the circle diagram is extended to include in addition to the usual factors involved, the effects of conductor size, spacing, and length. The method is particularly advantageous for use with short lines wherein capacitance is small. While this method can be used also for long lines, it loses its directness and generality in such cases, and much additional calculation becomes necessary. The treatment therefore will be restricted to the case of negligible capacitance.

Symbols used throughout the entire discussion are shown in Table I.

Table I—Symbols

P_R = in phase receiver power per phase in kw.
Q_R = quadrature receiver power per phase in kva.
E_R = receiver voltage to neutral in kv.
E_S = sending voltage to neutral in kv.
r = conductor resistance per mi. in ohms.
x = conductor reactance per mi. in ohms.
z = conductor impedance per mi. in ohms.
s = length of one conductor in mi.
f = frequency in cycles per sec.
D = conductor spacing in in.
a = conductor area in cir. mils.
ρ = resistance of conductor in ohms per mil-ft.

Written specially for ELECTRICAL ENGINEERING. *Not Published in pamphlet form.*

The well-known general equation for the circle diagram is as follows:

$$\left[\frac{P_R}{E_R^2} + \frac{r}{z^2 s} 10^3\right]^2 + \left[\frac{Q_R}{E_R^2} + \frac{x}{z^2 s} 10^3\right]^2 = \frac{E_S^2}{E_R^2 z^2 s^2} 10^6 \qquad (1)$$

This equation represents, for a specific line, a set of concentric circles the radii of which are dependent upon the ratio of sending to receiving voltage. The center of all the circles does not coincide with the origin but may be placed in the second quadrant at a point such as c in Fig. 1. The coordinates, l and m, may be seen from equation (1) to be:

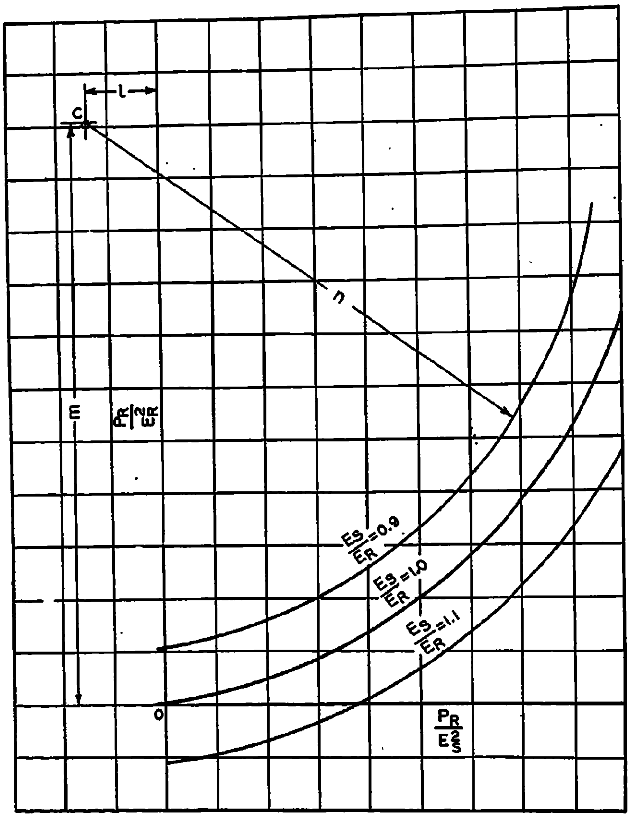


Fig. 1. General circle diagram for transmission lin neglecting capacitance, where l and m are as shown in equations (2) and (3)

$$l = \frac{r}{z^2 s} 10^3 \qquad (2)$$

and

$$m = \frac{x}{z^2 s} 10^3 \qquad (3)$$

If the circle radius be denoted by n, then

$$n = \frac{E_S 10^3}{E_R z s} \qquad (4)$$

From equations (2), (3), and (4) may be seen that the coordinates of the center c of the family of circles and their radii are dependent upon the values of r, x, and s. These constants in turn are functions of the conductor size, spacing, and length. The usual formulas for resistance and reactance per mile may be written thus:

$$r = \frac{5280 \rho}{a} \text{ ohms per mi.} \qquad (5)$$

$$x = 2 \pi f \left(741.1 \log_{10} \frac{2 D 10^3}{\sqrt{a}} + 80.47\right) 10^{-6}$$

$$= 0.00466 f \log_{10} \frac{2570 D}{\sqrt{a}} \text{ ohms per mi.} \qquad (6)$$

The constants l, m, and n now may be written in terms of a, s, and D.

$$l = \frac{5280 \rho 10^3}{a s \left[\left(5280 \frac{\rho}{a}\right)^2 + \left(0.00466 f \log_{10} \frac{2750 D}{\sqrt{a}}\right)^2\right]} \qquad (7)$$

$$m = \frac{\left(0.00466 f \log_{10} \frac{2570 D}{\sqrt{a}}\right) 10^3}{s \left[\left(5280 \frac{\rho}{a}\right)^2 + \left(0.00466 f \log_{10} \frac{2750 D}{\sqrt{a}}\right)^2\right]} \qquad (8)$$

$$n = \frac{E_S 10^3}{E_R s \sqrt{\left(5280 \frac{\rho}{a}\right)^2 + \left(0.00466 f \log_{10} \frac{2750 D}{\sqrt{a}}\right)^2}} \qquad (9)$$

To determine how the locus of point c is affected by any one of the three variables a, s, or D, let two remain fixed while the third is allowed to vary. In Fig. 2 the distance s is arbitrarily taken as 10 mi. and the frequency f as 60 cycles. By taking a series of fixed values of D and plotting the locus due to variation in conductor area for each, a set of curves is found of which $F b$ is an example.

Similarly by taking a series of fixed conductor areas a and allowing the spacing D to vary, another set of loci is obtained as illustrated by $G H$. Thus for this particular line of 10-mi. length the center may be located for any spacing and conductor area if a sufficient number of curves are plotted. While the center is varying in position due to a and D, the radius n also is affected. From the geometry of the figure

$$o c = \sqrt{l^2 + m^2} - = \frac{10^3}{z s} \qquad (10)$$

From the ratio of n to $o c$ in equations (4) and (10)

$$n = \frac{E_S}{E_R} o c \qquad (11)$$

The length of the corresponding radius for any position of c is therefore equal to the distance from c to o multiplied by the voltage ratio.

With the construction as outlined the diagram is general in regard to voltage. Once E_R is chosen the scales on the two coordinate axes become directly proportional to the quadrature and in phase receiver power. E_S is determined of course by the voltage ratio selected.

To determine how the diagram can be adapted for values of s other than that for which the diagram is drawn, (10 mi. in this case), it is necessary only to examine equations (2), (3), and (4). These equations show that for a given set of values of the constants r and x, or a and D, l, m, and n vary inversely as s. Therefore if a diagram for a line of 20 mi. is desired it is necessary only to divide the distances l, m, and n by two. An equivalent process which avoids the construction of a new set of curves is to divide the scales on the axes by two. In general then for any length s' the scale readings on the axes should be multiplied by $10/s'$.

As an example of the use of the chart, consider a transmission line with the following data:

Line voltage = 110 kv.
Spacing = 15 ft.
Conductor size = 350,000 cir. mils
Length = 20 mi.

Suppose that the corrective kva. at no-load is to be determined assuming a voltage ratio of 1.1. The circle drawn in Fig. 2 represents this case. The intercept on the horizontal axis is 12.5 units lagging. Then for a length of 20 mi.,

$$\frac{Q_R}{E_R^2} = 12.5 \times \frac{10}{20}$$

$$Q_R = 12.5 \times \frac{10}{20} \times \left(\frac{110}{\sqrt{3}}\right)^2$$

$$= 25{,}200 \text{ kva. per phase}$$

Other applications of the chart to practical every day problems can be shown to be equally simple.

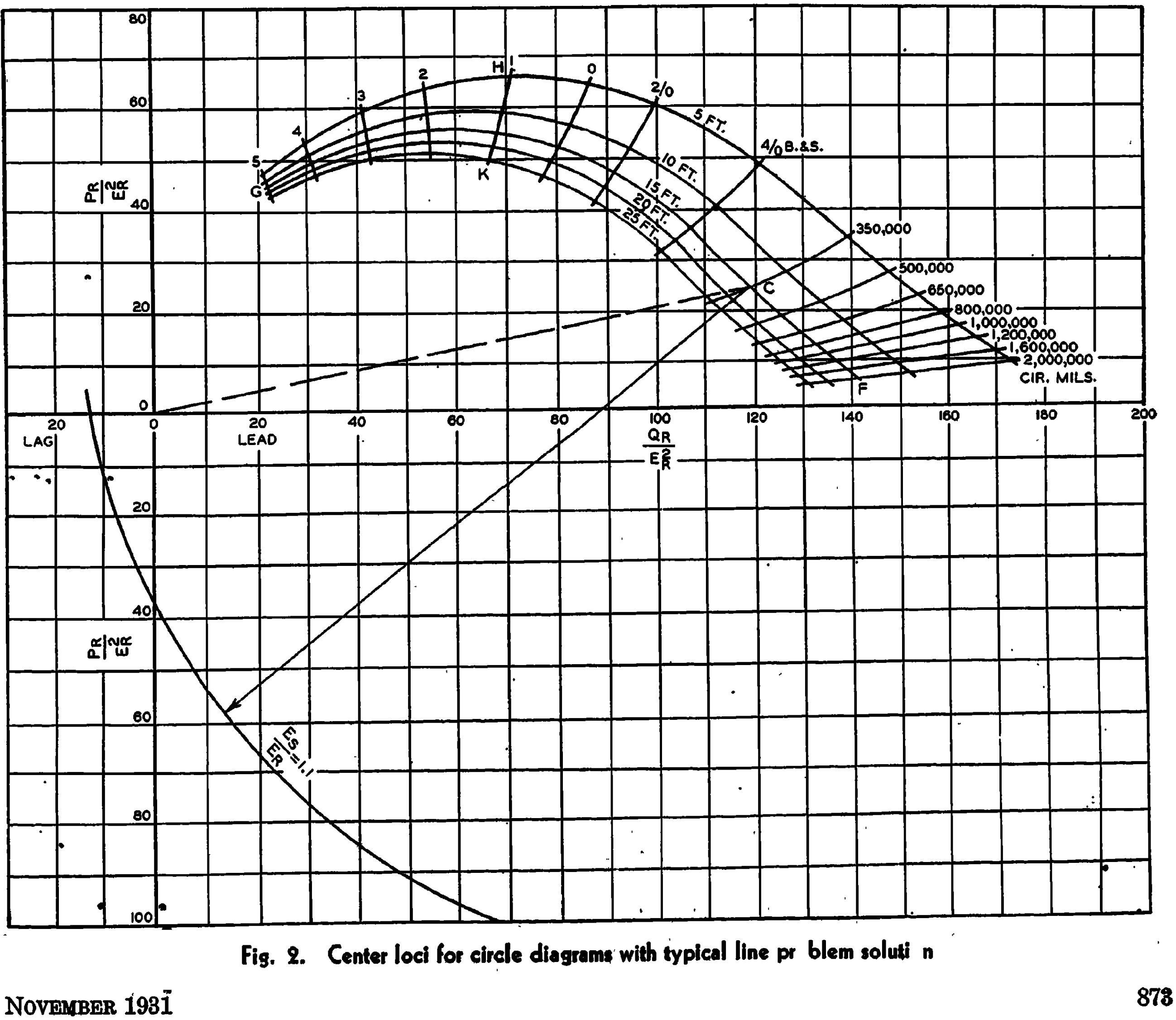


Fig. 2. Center loci for circle diagrams with typical line problem solution

Simplicity and Economy of Oil Filled Cable

Oil filled cable has been developed for successful use at the highest operating voltages. Attention now is being focused on the economies of oil filled cable systems and on means of simplifying their installation, with a resulting freedom from failure due to mechanical causes. The three articles which follow the short introduction below, discuss these factors.

DURING the past four years large installations of 132-kv. oil-filled cable and others of lower voltage rating have been placed in service. The electrical performance of all of these installations has been outstanding and each successive installation has represented an improvement in the way of simplification and economy. For ratings above 70 kv., oil filled cable is superior to the solid type in every respect; and it appears that the rating of oil filled cable can be extended to 220 kv. when required.

The term "oil filled" as applied to impregnated paper cable is understood ordinarily to indicate a cable in which the impregnating compound is of such viscosity as to be fluid at all operating temperatures. Such a cable must be constructed to permit free passage of the oil longitudinally and radially, and must be connected to a suitable oil supply. To keep the hydrostatic head of the oil from becoming excessive, oil stop joints must be inserted in the cable.

When properly constructed, such a cable system presents a number of advantages over solid cable. The free ebb and flow of the saturant removes the danger of heat expansion and consequent formation of bubbles or voids in the insulation under repeated load and temperature cycles. The deterioration of insulation is no longer an important factor to contend with, higher operating temperatures may be used, the voltage and current ratings may be increased considerably, and the thickness of insulation may be reduced. For a given size of duct more power can be carried. The dielectric loss of oil filled cable is quite low and there have been no indications of an increase in loss with time and service. Flaws and defects in the lead sheath result merely in a slow leakage of oil, which can be located and repaired at any convenient time. In solid cable the first warning of such defects is electrical service failure caused by the entrance of moisture and air.

In addition to improved characteristics of oil filled cable, the cable accessories have been developed so that the installation and operation of cable systems has been considerably simplified and the cost reduced. This reduction in the difficulty of installation is of considerable importance and should do much to make the use of oil filled cable at the higher voltages widespread.

Economics of High Voltage Cable

Careful studies have been made of the economics of the various types of cables for application in the Chicago district. The conclusions resulting from these studies are surprisingly definite, and indicate the trends in high voltage cable practise, especially as relating to the oil filled type.

By
D. W. ROPER
Fellow A. I. E. E.

Commonwealth Edison
Company, Chicago

OIL FILLED CABLE for operation at 132 kv., placed in service in Chicago in 1927, was designed in 1925 to have the largest carrying capacity commercially feasible for that voltage in the state of the art as it then existed. In the ensuing years improved oil and new designs of oil supply tanks simplified the design of the terminal to the extent indicated in Fig. 1; shipping the cable full of oil and the development of methods of making joints on the cable full of oil reduced the factory cost of the cable and the cost of installation in the field; successful operating experience on lower voltage cables with devices and methods for eliminating sheath losses had removed the limitation on the economical size of the conductor. As a result

---

From "Economics of High Voltage Cable" (No. 31-108) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

of these developments, a second line was installed in 1930 in the same conduit as the first line, having a carrying capacity 75 per cent greater but at 20 per cent less cost. These two cables are illustrated in Fig. 3.

While the design of the line installed in 1930 was under consideration a number of other questions regarding underground transmission in the Chicago district arose, as follows:

1. What is the maximum economical size of single-conductor cable for connection between the 12-kv. bus and a 60,000-kva. transformer bank?

2. Is there any economy in the use of oil filled cable for 66-kv. service?

3. What is the maximum load per line that can be carried on 132-kv. oil-filled cable in 4-inch ducts?

4. Can 220-kv. cable be obtained if desired, and what will be the approximate cost?

It therefore was decided to review for Chicago conditions the entire subject of high voltage cable so that in addition to answering these questions, it would be possible to determine what changes in existing practise were indicated by recent developments.

Preliminary calculations on typical cables in use in Chicago indicated wide differences in the relative amounts of the various items entering into the initial cost and annual charges; and further, that the cable with the lowest total annual charges might not always be the one with the lowest first cost. Accordingly the plan was adopted of calculating curves showing, for Chicago conditions, the variations of the initial cost and annual charges for the entire range of commercial sizes so as to determine the most economical transmission voltage and type of cables for various Chicago conditions. These curves are given in Figs. 2 and 4. The investment costs include labor and supervision, conduits and manholes, joints and accessories, and cable. The annual charges include the cost of failures, maintenance, insulation loss, sheath loss, copper loss, depreciation, and interest and taxes.

The calculations were confined to cables for the transmission voltages in use except that, with some assistance from the manufacturers, 220-kv. cable was added. In determining the size, type or voltage of transmission cable, due consideration should be given to the effect on the entire system of generation, transmission and distribution of which the cable is to be a part.

As the *relative* initial and annual costs of various types were desired, it was considered more important that the unit cost figures be the same for all calculations than that they should fit any particular case. Accordingly the same physical constants, unit costs, and conditions were used throughout the calculations. Among the factors investigated which affect initial and annual costs were elimination of sheath losses on single-conductor cables, dielectric loss, maximum permissible operating temperature, load factor, and improvement in power factor of the system due to the charging current of the cables.

A study of the curves leads to the following conclusions:

1. The most economical cable for a given set of conditions should be determined by considering the total annual charges, rather than the first cost.

2. The inclusion of the terminal charges makes but slight difference in the *relative* costs of the various types and voltages of cable. This indicates that the relative costs of the various types and voltages of cable would be altered only slightly by assumptions somewhat different from those used in the calculations.

3. For every load there is one type of cable and one transmission voltage which is more economical than any other combination.

4. For a given type and voltage of cable, maximum economy generally is found with larger cables than are in ordinary use.

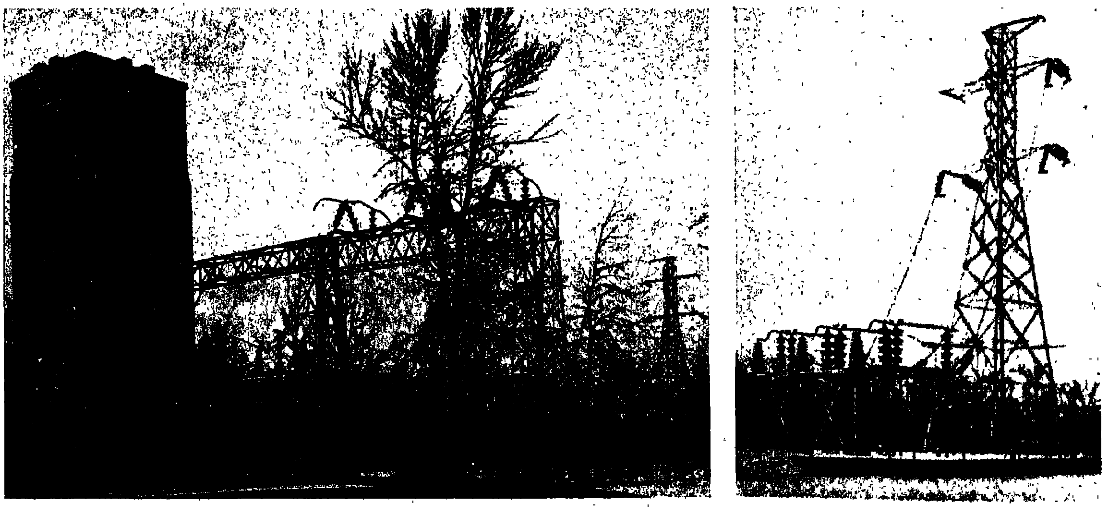


Fig. 1. The electrically heated terminal and oil reservoir tower of the 132-kv. cable line installed in 1927 is shown on the left, while on the right is the outdoor terminal of the 132-kv. line installed in 1930

5. Three-conductor cables are the most economical for loads up to about 50,000 kva. For the upper half of this range, three-conductor, 66-kv., oil-filled cable is the most attractive, but requires larger ducts than are now in ordinary use.

6. For loads above 50,000 kva. per line, single-conductor cable should be used.

7. The elimination of sheath losses by the use of insulating joints and bonding transformers permits the efficient use of large single-conductor cables between the 12-kv. bus and transformers for high voltage lines. The reduction in annual charges is indicated in Fig. 5.

8. For cable to operate at 66 kv., a moderate reduction in the cost of oil-filled single-conductor cable and in the cost of the joints and accessories would bring the oil filled type in competition on a cost basis with cable of the ordinary type.

9. For loads of the order of 100,000 kva. per line, oil-filled, 66-kv., single-conductor cable is preferable to the ordinary type when the overall diameter of cable is limited by the size of the ducts in existing conduits.

10. There is no economy in using 132 kv. for tie-lines between stations in Chicago until the required carrying capacity exceeds 125,000 kva. per line. In so far as carrying capacity of the cable is concerned, there is no occasion for increasing the transmission voltage above 132 kv. until the required capacity per line exceeds 250,000 kva.

11. The cost of cable for 132 kv. and higher voltages will probably limit its use to underground extensions, within large cities, of long overhead transmission lines from distant stations.

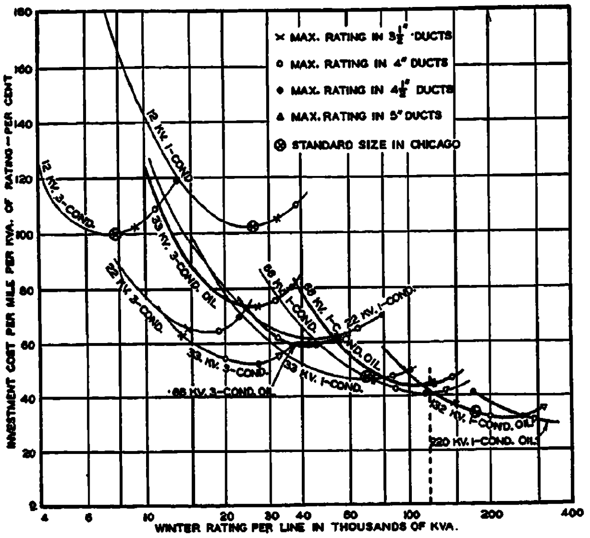


Fig. 2. Relative investment costs of underground lines, excluding terminals

One cable per duct; 6 to 10 identical cables per conduit. Minimum cost for 12-kv. three-conductor cable assumed as 100 per cent

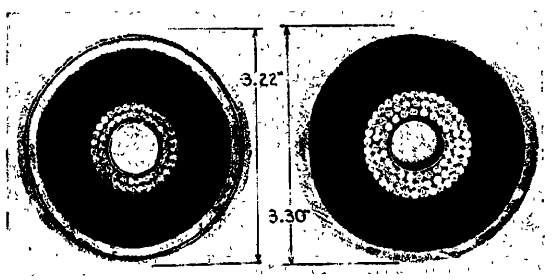


Fig. 3. The 132-kv. oil-filled cable for the 103,000-kva. line installed in 1927 (left) and for the 188,000-kva. line installed in 1930 (right)

12. As the fixed charges are about three-fourths of the total annual charges, the best way to reduce annual charges is to reduce first cost.

In determining the best transmission cable for a given purpose, the decision should not be restricted by preconceived ideas of the relative importance of transmission voltage, dielectric loss, skin effect, maximum efficiency of insulation, Kelvin's law, the size or number of ducts in the conduit, or other physical laws and constants; but, by taking all such subjects into consideration, the type, size and voltage of cable and conduit details should be determined so as to secure the lowest annual charges for the given conditions.

COMPARISON OF INSULATION

At current prices and with the thicknesses of insulation now specified by the manufacturers for the various operating voltages, 66-kv., three-conductor, oil-filled

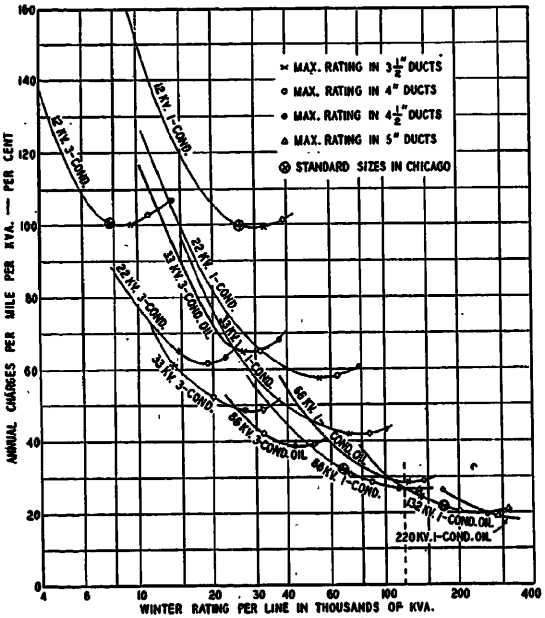


Fig. 4. Relative annual charges for underground lines, excluding terminals

Annual load factors: 12 to 33 kv., 45 per cent; 66 to 220 kv., 60 per cent. Minimum charges for 12-kv. three-conductor cable assumed as 100 per cent

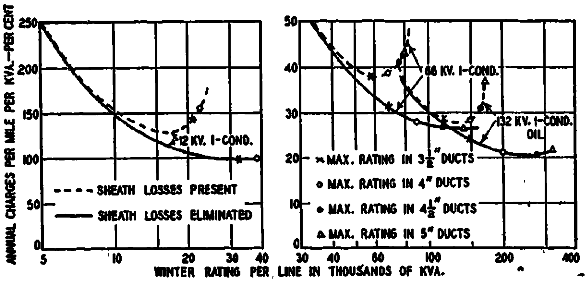


Fig. 5. Effect of sheath losses on annual charges for single-conductor cables. Load factors and vertical scale same as for Fig. 4

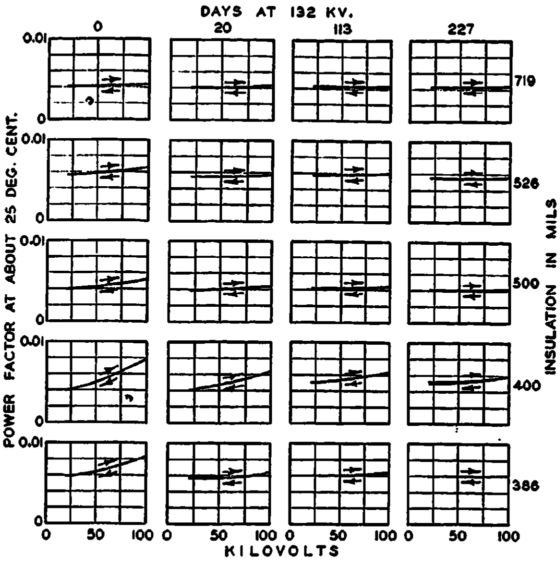


Fig. 6. Typical power-factor curves for 132-kv. oil-filled cable subjected to daily load cycles with maximum copper temperature of about 70 deg. cent.

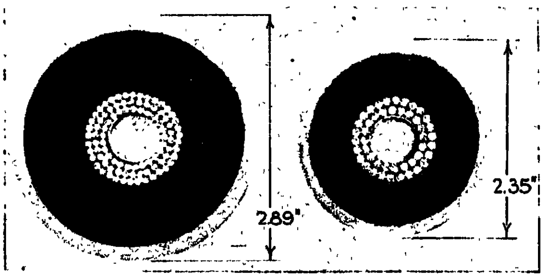


Fig. 7. 600,000-cir. mil commercial cable on the left and 475,000-cir. mil experimental cable on the right, both f r same ampere capacity at 132 kv.

cable is the most economical type for loads ranging from about 25,000 to 48,000 kva. For loads ranging from about 48,000 kva. to 120,000 kva. per line, single-conductor cable with the ordinary type of insulation is the most economical. A reduction of about 10 or 15 per cent in the cost of oil filled cable and a reduction of about 30 per cent in the cost of the accessories for this type of cable would place the oil filled type in price competition with the ordinary type over this range of loads. Further reductions in the price of oil filled cable and accessories will be necessary in order to place it in competition with the ordinary type of insulation for lower voltage cable.

As indicated by Fig. 6, investigations on oil filled cable with reduced thickness of insulation, operated at 132 kv., show no adverse changes in the insulation as determined by power-factor measurements after operating for eight months with daily load cycles. Apparently the thickness of insulation now used for this voltage could be reduced safely. Present information indicates that the thickness of oil filled insulation for 132 kv. may be determined by the transient voltage disturbances rather than by the normal stresses due to the operating voltage.

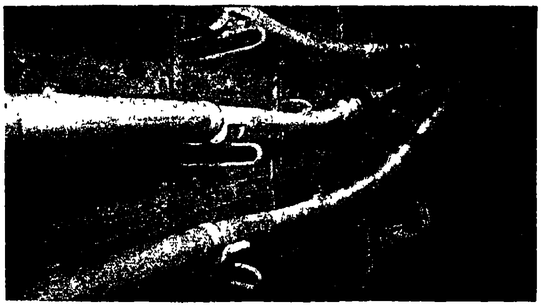


Fig. 8. Installation of equipment for eliminating sheath losses on 132-kv., 188,000-kva. cable

Left—Normal cable joints before fireproofing
Center right—Insulating joints in cable sheaths
Lower right—Bonding transformer for reducing sheath voltages

A reduction in the present thickness of the insulation of oil filled cable appears warranted by the remarkable operating record of the installations in this country, the record being that there have been over 250 mile-years of operation of the cable without any failures of the insulation. A similar record has been made by one make of 66-kv. cable with the ordinary type of insulation. This should indicate also the reasonableness of reduction of the ordinary type of insulation for 66-kv. cable.

Whether the oil filled type will displace the ordinary type at 66 kv. and lower voltages, or the ordinary type compete with the oil filled type at 132 kv., depends on the relative rates of improvement and reductions in cost of the two types of insulation with unrestricted competition.

Present indications are that the maximum temperature limit for high voltage cable may be imposed by the limitations of the lead sheath rather than by the properties of the insulation. It appears possible that the advancements in the art in the next ten or fifteen years will permit the insulation thickness for 132-kv. cable to be reduced from 719 mils to 500 mils, and the maximum temperature to be increased from 65 deg. cent. to 80 deg. cent. Fig. 7 shows the extent to which the diameter of the cable would be reduced by these changes.

When all the research investigations now in progress or contemplated by the utilities, universities and manufacturers have been brought to a successful conclusion the following results should have been attained:

1. Cables of all types and voltages will be operated at a maximum temperature of 85 to 90 deg. cent. without fear of deterioration.

2. The expensive oil reservoirs and accessories on oil filled cable will be eliminated due to:
    - (a) Increase in the elastic limit of the cable sheath.
    - (b) Reduction in the thermal coefficient of expansion of the oil.
    - (c) Making the insulation somewhat compressible under moderate pressures existing with the lead sheath.

3. An installation of oil filled cable will be no more complicated than a present-day installation of ordinary type of cabl .

4. Cable of subnormal quality will be eliminated by tests at the factory.

5. The initial cost per kva. of 66-kv. cable completely installed will be from 30 to 40 per cent below the present cost of the ordinary type.

6. Cable failures due to all causes will not exceed one per 100 miles per year.

If all of these results should be achieved within the next fifteen years, it would be no more startling than a statement of the present day state of the art would have appeared fifteen years ago. To keep pace with the advancements being made by the manufacturers, the utilities must improve their standards of design and workmanship.

Layout of Oil Filled Cable Systems

Problems concerned with the supply of oil largely govern the layout of oil filled cable installations. Consideration must be given not only to the characteristics of the oil itself, but also to certain properties of the cable and duct structure governing the volume and pressure of oil required.

By
G. B. SHANKLIN
Member A. I. E. E.

F. H. BULLER
Member A. I. E. E.

Both of
General Electric Co.,
Schenectady, N. Y.

REQUIREMENTS which must be met in order that the operation of oil filled cables be successful include the following:

1. A stable non-freezing oil of superior electrical properties. This oil should have predetermined viscosity characteristics that give assurance against void formation in the cable cross-section and excessive loss of pressure along the feed channels.

2. The wood pulp paper shall be of high quality, compactly and uniformly applied, and of predetermined density.

3. All impurities such as moisture and gas, both free and in solution, shall be removed from the cable during manufacture, and from all accessories and fittings during installation.

4. Positive pressure shall be maintained at all times inside the entire length of cable and other parts of the oil system.

5. The oil pressure should never exceed the safe working limits determined by the mechanical strength of cable sheath and accessories.

In laying out the most effective and economical installation of oil filled cable, primary consideration must be given to the problem of oil supply including the rate of expulsion and absorption of oil by the cable, oil pressure drop along the feed channels, total expulsion or absorption of oil between the extreme limits of no-load winter temperature and full-load summer temperature, and the characteristics of available reservoirs to take care of volumetric changes in the oil caused by these fluctuations in temperature.

Typical oil demand curves of the cable, upon the sudden dropping of load, are shown in Fig. 9. Cable 1 has an inside diameter of core of 0.5 in. and a copper conductor cross-section of 600,000 cir. mils, with an over-all diameter of 2.84 in.; while cable 2 has an inside diameter of 0.5 in., a copper cross-section of 475,000 cir. mils, and an over-all diameter of 2.3 in. The measurements were made for two different oil pressures maintained in the hollow core as shown. Measurements of oil demand when the same load is applied also were taken, but the two sets of measurements coincided so closely that the latter data will not be given. The fact that these measurements coincided indicates that voids were not formed when the load was dropped. Also, if voids had been formed, the demand measurements with low oil pressure would be less than with the high pressure. As indicated in Fig. 9, these measurements were identical. Also, the theoretically calculated curves of Fig. 9, based on the assumption that no voids were formed, are in almost exact agreement with the test measurements.

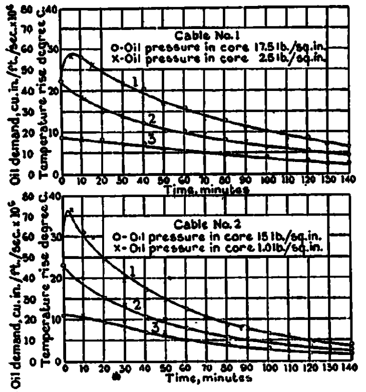


Fig. 9. Curves of (1) oil demand, (2) copper temperature rise, and (3) sheath temperature rise, after dropping load. Calculations are shown by curves, and test results by points

Oil pressure drop along feed channels and piping during periods of oil flow can be calculated with acceptable accuracy only when the inner surface is smooth and cylindrical, and the rate of flow is less than turbulent. The friction factor can be calculated to allow for surfaces which are not smooth, when a spiraled supporting member is used, but it is usually necessary to confirm such calculations by test.

The total oil required is a direct function of cable length and the two extreme limits of temperature met with in service. For underground cable these limits are usually assumed as 0 deg. cent. no-load winter temperature, and 70 deg. or 75 deg. cent. full-load summer temperature. The total oil requirements can be

---

From "Characteristics of Oil Filled Cable" (No. 31-97) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

calculated on this basis. Usually 40 per cent over the theoretical requirement is added to the reservoir capacity as an emergency surplus and to safeguard against possible discrepancies in calculations or wrong adjustment of reservoir content. For typical single-conductor and three-conductor cable, the total oil requirement based on the theoretical value plus 40 per cent varies from 0.5 gal. to 2.0 gal. per 100 ft. of cable.

The types of oil reservoirs which have proved most useful and desirable for oil filled cable installation are the gravity-feed reservoir and the balanced-pressure reservoir. These reservoirs are identical in design and construction with the exception that the outer rigid enclosing tank of the gravity-feed reservoir is open to the atmosphere through a breather, maintaining practically constant atmospheric pressure on the oil. On the other hand the balance-pressure reservoir has a sealed gas-tight outer tank, maintained under variable gas pressure. Both types follow the established principle of segregating and sealing-off the cable oil system against exposure to gas or other impurities. The gravity-feed reservoir must be elevated of course above its surroundings and in locations where elevation is undesirable or impractical, the balanced-pressure type may be used. These are adjustable so that units at different elevations can be made to work together.

In addition to the four factors discussed above, dealing with oil supply, there are a number of other characteristics which must be known before an oil filled cable installation can be laid out properly. One of these is the steady and transient thermal characteristics of the cable and surrounding duct structure, curves of which are given in Fig. 10 for cable 1 previously described. If full load on the cable had been dropped, the maximum rate of oil supply would have been greater than when dropping half load as in Fig. 10; however, the maximum pressure drop would have been less. This is accounted for by the difference in oil viscosity.

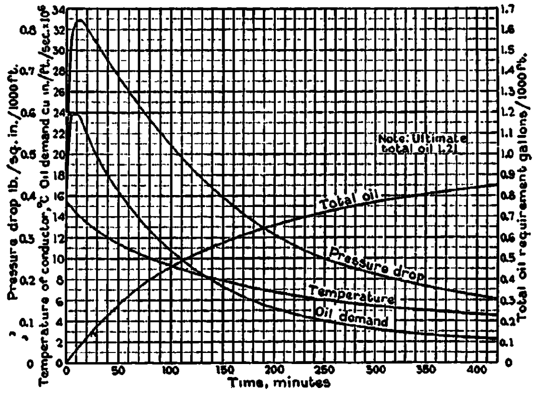


Fig. 10. Effect of dropping half load from six cables in duct bank. Based on winter conditions of 0 deg. cent. ambient earth

All of the necessary factors for cable 1 have been described and we are now in a position to lay out an actual installation. The contour of the duct run, spacing between manholes, dimensions of manholes and other practical considerations will determine the best and most economical layout. Pressure drop along the core, minimum oil pressure at high point, maximum pressure at low point and other factors will determine the location of oil stop joints and the type of oil feed for each section between stop joints. Two typical sections will be selected for discussion.

First, assume a duct contour as shown in Fig. 11, with stop joints at position 0 ft. and 3,000 ft. The sheath of cable 1 has no reinforcement and steady oil pressure at the lowest point (1,500 ft.) must not exceed 15 lb. per sq. in. Also it is desirable to avoid either a steady or transient oil pressure lower than atmospheric at any point in the oil feed system, consisting of reservoir cells, piping, stop joints and cable core. From the previous work it is known that the total rated oil capacity of the reservoir units for this length of cable is 25 gal.

Balanced-pressure reservoir feed obviously is out of the question, since the hydrostatic pressure from position 0 to 1,500 ft. is already the full allowable 15 lb. If gravity-feed units are placed at position 0 ft. and at an elevation slightly above the stop joint, the minimum pressure in the cable core when full and half-load are dropped in the winter-time is shown by curves 1 and 3. Both of these curves intersect the cable contour, and the oil system beyond these points of intersection would be at a pressure below atmospheric for several minutes. If the gravity-feed reservoirs are raised to sufficient height as shown by curve 5, this condition could be avoided; but this solution is not desirable since instead of mounting the reservoir units directly in the manhole, it would mean an expensive reservoir housing above ground level. Also, safe working pressure of 15 lb.

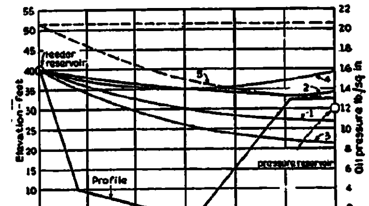


Fig. 11. Typical section of cable with feeder and pressure reservoirs

Feeder reservoir rated 25 gal.
Pressure reservoir rated 3 gal. oil, 15 gal. gas.

Curve 1—Pressure curve while full load is dropped in winter, feeder reservoir only

Curve 2—Same condition as Curve 1 with feeder-pressure reservoir combination

Curve 3—Pressure curve when half load is dropped in winter, feeder reservoir only

Curve 4—Same as Curve 3, with feeder-pressure reservoir combination

Curve 5—Same as Curve 3, shows height to which feeder reservoir must be raised to avoid vacuum at the far end under all conditions

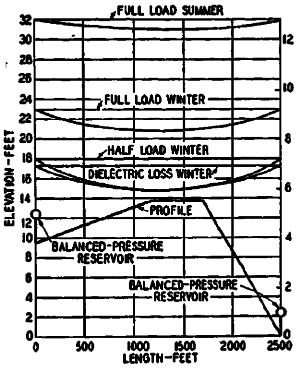


Fig. 12. Typical section of cable with balanced pressure reservoir

Oil volume—
10 gal. each reservoir
Gas volume—
41.6 gal. upper reservoir
54.0 gal. lower reservoir

would be exceeded at the lowest point of cable contour.

The real solution is to leave the gravity-feed units at stop-joint level and connect a small pressure reservoir at the low end of the section. This pressure reservoir functions only during transient periods of temperature change and during these periods assists in maintaining cable core pressure within prescribed limits. Curves 2 and 4 with pressure reservoir connected show the improvement in pressure characteristics accomplished by the addition of this small unit.

On level ground or where the profile of a given section is such that the feeder-pressure combination just described cannot be used without resorting to expensive mounting of reservoirs above ground level, the so-called balanced-pressure feed proves very convenient and economical. Fig. 12 shows a 2,500 ft. section of cable line having a contour that can be taken care of most conveniently by balanced-pressure feed. In all other respects the assumptions are the same as outlined for Fig. 11. The total rated oil capacity is found to be 20 gal. This should be divided equally, one 10-gal. balanced-pressure unit being placed at each end, the relative elevations of these reservoirs being as shown in Fig. 12.

The gas capacity of these units and their initial volumetric and pressure settings are so selected that each reservoir takes care of exactly half of the cable section. Also, the pressure at the highest point in the oil system must never drop below 1 lb. above atmospheric, and the pressure at the lowest point must never exceed 15 lb.

The pressure along the cable core under various limiting conditions is also shown. It will be noted that dropping either half-load, or merely dielectric loss in the winter and full-load pressure in the summer represent the extreme limiting conditions.

There are many factors that determine the best and most economical system of oil feed and general layout of oil filled cable installations. The best system might vary anywhere from a stop joint and reservoir in every manhole, where very rugged contour is encountered, to complete exclusion of stop joints on level ground. Generally speaking, the use of stop joints should be reduced to a minimum. Stop joints should be used merely for segregation, since the advantages gained are nullified by the additional expense and the limited amount of reservoir oil available for emergency use in case of accidental leakage.

Accessories for Oil Filled Cable

The development of more satisfactory cable joints, terminals, and reservoirs has greatly simplified the installation of oil filled cable and increased the reliability against mechanical failures.

By
R. W. ATKINSON
Fellow A. I. E. E.

D. M. SIMMONS
Fellow A. I. E. E.

Both of
General Cable Corp.,
New York, N. Y.

PARALLEL with the development of an oil filled cable for high voltage use, notable progress has been made in securing the simplicity of installation afforded by the ordinary type of cable. This factor is of considerable importance to the general use of oil filled cable for high voltages, as the difficulty of installing the earlier system handicapped its use considerably. A background of very successful practical experience now has been secured with the newer and simpler types of joints, terminals, and accessories.

The fundamental features about which this system has been built are:

1. Shipment of cable filled with oil, and without field evacuation and reimpregnation.

2. Stop joints of moderate size and cost, and a rapid and reliable technique of installation, making practicable oil feed lengths as short as desired.

3. Reliable oil feed system, including compact designs of expansion oil reservoir with oil volume indicator, and an automatic signal system designed to give to oil filled cable the same superiority over solid type in freedom from service failures due to most types of mechanical causes that it now enjoys with respect to electrical trouble.

4. For multiple-conductor cable, provision of oil channels in the filler spaces, making the system equally applicable to single-conductor and three-conductor cables.

From "Oil Filled Cable and Accessories" (No. 31-100) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

The cross-section of single-conductor 132-kv. cable in Fig. 13 shows the oil channel which is provided in the center of the conductor and also a number of longitudinal slots in the inner surface of the sheath which are sometimes provided to facilitate the flushing out of the last traces of air by passing degasified oil radially through the insulation. In all cases, the cable is completely dried and impregnated in the factory after leading, and shipment and installation without loss of oil is made possible by special pressure transportation reservoirs.

A cross-section of the oil supply reservoir is shown in Fig. 14. This reservoir is of the simplest type possible, with a single-unit metallic bellows enclosed in gas-tight metal casing. Severe tests have demonstrated these units to have a cyclic life far in excess of that required in service. The oil supply is contained in the bellows and pressure is maintained by gas in the outer casing. A light compression spring sufficient to overcome the inherent springiness of the bellows is used to supplement the gas pressure, and insures the oil pressure being always higher than the gas pressure, so that in case of a bellows leak the oil will leak outward into the gas instead of gas passing into the oil; and in addition, the bellows will be gradually compressed to the point where the low-volume contactor will operate.

Low-pressure and low-volume oil indicators are provided to operate mercury-tube contactors connected in the signal system. These signals are transmitted to a conveniently located control board which is equipped with a simple bridge by which the precise location of the trouble may be determined quickly.

CONDENSER JOINTS AND TERMINALS

The large increase in dielectric strength for a given thickness of insulation resulting from the use of oil filled cable has greatly increased the difficulty of producing satisfactory joints and terminals for use on commercial lines, and has resulted in the adaptation of the condenser type of construction to this purpose.

The development of a reliable and comparatively inexpensive stop joint, moderate in size and simple to install, is a most important feature of the oil filled cable system. The availability of such a joint simplifies the problems of oil feed, and of effective sectionalizing as regards oil supply. This joint utilizes the condenser principle, and in addition to effecting reduction in space requirements over earlier stop joints, it has shown electrical strength in excess of anything previously reported. By providing substantially uniform distribution of stress longitudinally it makes possible the use of the very simple "stop tube" arrangement. This construction reduces the joint insulation in the field to little more than a simple assembly process. In addition to the barrier-type terminals which have been used for a number of years on many commercial installations up to 66 kv., and on experimental lines up to 132 kv., terminals using the condenser principle are available also for the higher voltage.

The great problem in terminal and joint design is to prevent concentration of longitudinal stress in the neighborhood of the edge of the sheath, and to secure a substantially uniform potential gradient along the surface of the cable insulation between the conductor and the sheath. This latter factor is complicated by the fact that paper insulation has a low dielectric strength longitudinally in comparison with its strength radially.

For some time it has been recognized that stress distribution by means of a series of capacitances would be a complete solution for alternating potentials, but difficulties in the details of the practical application of this method have prevented its extensive use. These difficulties now have been overcome and two designs developed fully utilizing the condenser principle. In the design first produced commercially, and used for both joints and terminals, the condensers are annular and mounted on a tube which slips over the exposed end of the conductor insulation. The construction of a terminal of this type is shown in Fig. 15. Similar principles are used successfully in the design of joints.

NEW CONSTRUCTION MORE ECONOMICAL

A new form of construction has been perfected recently which is much lower in cost and which for joints has displaced entirely the earlier one. In this design, shown in section in Fig. 16, the condensers take the form of a nest of concentric metal cylinders *A* insulated from each other by saturated paper. At the ends of these cylinders are radial sections *B*, which are in effect conducting disks, terminating at their inner edges in short cones *C* which control the longitudinal distribution of voltage along the exposed cable insulation.

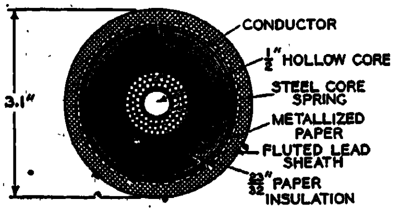


Fig. 13. Single-conductor oil filled cable for 132-kv. service

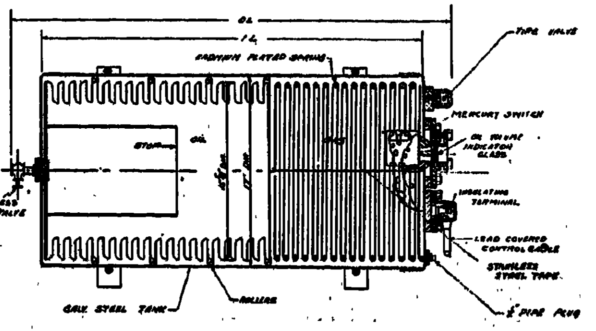


Fig. 14. Pressure type variable-volume oil reservoir

The capacity between successive cylinders and their corresponding potential is controlled by varying the insulation thickness between them, or by the use of several cylinders connected in parallel as shown at *D*. The angle of the conical portion is calculated to give substantially uniform potential gradient between adjacent cones, and to prevent concentration of stress at the inner edges. This angle is smallest near the end of the sheath and increases toward the center of the joint.

In practise, the complete group of condensers is built up as a separate, self-contained unit. A long strip of paper is wound on a tube of rigid insulating material referred to as the "condenser tube" thin sheets of metal being inserted at appropriate intervals to form the cylinders *A*. The inner cylinder is connected to the cable conductor through a metal ring inset in the tube, and spring contactors mounted on the splice connector. The cones *C* and disks *B* are formed by winding on with the paper, narrow metal tapes fed from spools which move longitudinally to the axis of the joint to produce the desired taper. When the winding is finished the complete unit is incased in a thin sheet of corrugated copper, vacuum dried, and then saturated with insulating oil and the casing sealed, thus forming a compact unit which can be easily handled and installed by simply slipping it over the joined ends of the cables.

The longitudinal stress in the oil films between the condenser tube and stop tube, and between the stop tube and the conductor insulation, is controlled by the condenser construction and by the angle of taper used on the conical metal socket into which the stop tube is mounted at the outer end. With very thin high-strength cable insulation, however, the radial stress on the film within the stop tube may be excessive. To prevent this, it is ordinarily found desirable to build up the conductor insulation with a tube of impregnated paper slipped loosely over the end of the cable and tightened up by twisting. In this way the radial stress in the oil films may be kept well below that which will produce ionization. This same construction is used also with excellent results in non-stop joints and in terminals of both the barrier type and the condenser type.

INCREASED LONGITUDINAL STRENGTH

By this construction it has been possible to obtain substantially uniform longitudinal distribution of stresses. The limiting feature of design has become the actual longitudinal strength of thin oil films and of the impregnated paper in a direction parallel to its laminations. In earlier designs of joints and terminals it had not been possible to develop this strength, and consequently there has been very little previous work to determine specific values of electrical strength in this direction. For this reason a large number of tests has been made on laboratory samples simulating the conditions found in the condenser unit and using oil films approximately 1 mil thick. When tested at 20 lb. per sq. in. gage pressure, a longitudinal strength of 40 to 60 kv. per in. was indicated. No reduction of strength with time of application of voltage was observed. Breakdown voltage was roughly proportional to the square root of the distance between electrodes, and to the eighth root of the absolute pressure. On completely assembled joints having a total of 14-in. longitudinal creepage distance, tests have been made up to 300 kv. for approximately eight hours without failure, and proportional results have been obtained on smaller joints.

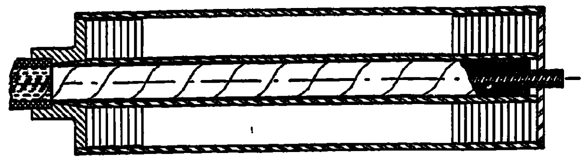


Fig. 15. Elements of test terminal with disk condensers

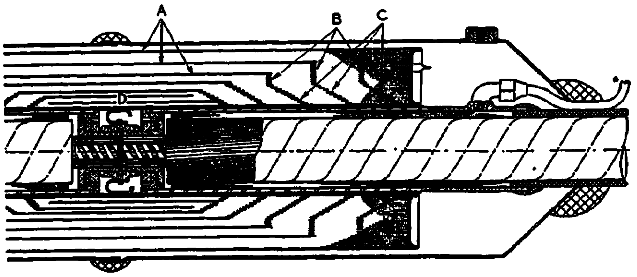


Fig. 16. Condenser joint with cylindrical condensers

In earlier designs of joints and terminals for very high operating voltage, the difficulty with concentration of stresses increased with increased voltage, so that a small increase in voltage necessitates an entirely disproportionate increase in dimensions. As a result, a rather definite limit was established beyond which further increase in voltage was impracticable. With the uniform distribution provided by the condenser construction, increase in voltage merely requires a proportional increase in the number of condenser steps and the design of joints and terminals for any desired voltage for which cables later may be built becomes a simple matter of adjustment of dimensions.

These developments have made possible a unified cable system combining the inherent advantages of the oil filled principle with certain features which contribute greatly to simplicity and reliability. These features include ease of installation, efficient sectionalizing, and provision for prompt detection of oil leaks or abnormal pressures. As a result, freedom from electrical failure, which is characteristic of oil filled cables, may be expected to be matched by freedom from service failures due to most of those external and mechanical causes which result in failures on the present solid systems.

The Transfer of Skill to Russia

A native of Russia, speaking the language and familiar with the customs and habits of its people, the author has come to the conclusion that Russia's principal problem in her industrial development is one of management. On the basis of 25 years of professional engineering experience in the U.S.A. and a recent 18-month professional engagement in Russia, this conclusion has been reached.

By
WALTER N. POLAKOV Consulting Industrial Engineer, New York

TO ACCOMPLISH the gigantic and ambitious program of changing within perhaps a few years the most backward country into a modern industrial land of Soviets is the aim and determination of the mass of the Russian population. The leaders of that country are charged with this tremendous responsibility and millions of workers, communists, and ordinary citizens are watching sharply every step toward the fulfilment of their Five Year Plan.

Last February the Conference of the Industrial Executives passed the resolution to accomplish this task in four years instead of five, and in the more essential industries in even three years. The speed of this progress was made the essence of the program. Stalin pointed out that in the past, Russia was defeated constantly because of its alluring richness and defenseless backwardness. Another reason for this acceleration is the dire need of consumers' goods such as clothing, shelter, and food, the shortage of which may be endured by the hardy and fatalistically inclined population for just so long, but not indefinitely. The third reason for this unheard of speed of development may be found, although it never has been admitted, in the psychology of the population. Four hundred years of despotic monarchy, browbeating officials, and economic slavery to landlords resulting in a low standard of living, were blended gradually with the passive slavic, almost oriental easy going slow tempo of the primitive agricultural life, so that in order to take the population out of this static inertia and accelerate it nothing but this kind of complete change to the great speed of preplanned activity would do.

The slogan "catch-up with, and overtake the leading industrial countries" coupled with the ambition formulated on banners and posters throughout Russia calling the people to become the "leaders of the world" gives them the courage to live in the anticipation of better days and easier life after the Five Year Plan is completed.

Meanwhile, they need machinery and the skill to use it. To build plants and factories and to open up the mines is relatively easy. To be sure, one needs cash or credit for the purchase of equipment, and as this must be bought in Europe or America, it involves export for exchange of Russian goods for foreign equipment. Since the world-wide industrial and financial crisis the prices went down, but the terms of orders previously placed remained. Hence, Soviets have to export more than they had planned in order to pay for the equipment under contract. This is obvious, and the people must put up with shortages of every kind at home.

Yet what is not so obvious is that after factories are built and machinery installed, goods must be produced. This constitutes a real problem and a particularly grave one under the circumstances.

COMPETENT MANAGEMENT NEEDED

Nowhere in the world is the old adage that, "large plants and perfect equipment is of no avail without proper management" as glaringly true as in Russia today. Since production rate depends primarily upon organization for execution of plans, it requires the executive direction and managerial skill and the technological knowledge and habits of modern industry.

In U.S.S.R. is found a remarkable political organization, but industry and politics are not congruent. To organize a revolution demands different qualifications from those necessary to organize production. The leaders of Russian development begin to sense this fact. Stalin bluntly pointed out on various occasions that his comrades failed to learn the technique of production management. He made this point very clear when the last year's records were announced, showing a 25 per cent increase of production, an unprecedented rate of growth, instead of the expected 31 per cent. This year's plan anticipates a further 41 per cent increase in production. Newspapers are full of appeals and warnings. Recently correspondents from Moscow heralded Stalin's new economic policy with the center of gravity shifted from construction and machinery to the operation and human element. This was inevitable. In our personal experience, a well equipped, fully manned machine tool plant raised its output more than 400 per cent in a few months by introducing the simplest methods of modern technique of management.

An address delivered June 18, 1931, before the New York Chapter of the Society of Industrial Engineers. *Not published in pamphlet form.*

What does it mean and what is the cause of it?

On the surface, it means that young Russian industry could save 75 per cent of the investment in new plants and factories if the other 25 per cent were managed properly, or that it could produce at least four times more on investments. But is this merely a theoretical consideration or is it a practical, immediate possibility?

In the past, the extent of Russian industry was insignificant when compared either with the natural resources of the country or with its present extension. This meant a relatively small number of engineers and executives. Many of that number are not available at present; some unwilling or psychologically unfit to render service under the vastly different social economic set-up. At the same time, hundreds of large industrial establishments being annually added and put into operation demand large cadres of executives and engineers. In parallel with the construction of new plants, Russia's plan provides for the establishment of new technical schools with short intensive training of a highly specialized engineering staff.

Most if not all large plants have technical schools under their aegis, seeing to it that young men and women are receiving necessary instruction in close contact with industry and meeting its needs. These students are workers themselves, with years of practical experience, working eagerly and tirelessly in various fields, gradually forming a new type of practical specialist so much needed in modern mass production based on standardized methods. Furthermore, foreign engineering contractors selling and installing equipment usually furnish instructors to demonstrate the use of their equipment and the process of manufacture.

But here the difficulty begins. Buying a machine on a guarantee basis so that it is capable of turning out such-and-such an hourly production, does not mean and cannot mean that the plant as a whole, even if completely and properly equipped with a full complement of productive and auxiliary equipment, actually will turn out the specified volume of finished product. The simple truth that such an efficient performance demands as an unconditional prerequisite a well-devised, systematic management and a competent executive control, is as yet not fully recognized by a sufficient number of the political and industrial leaders of that country.

SHOP EXPERIENCE LACKING

The lack of actual shop experience in administration and management and the enthusiastic belief in guaranteed "machine capacity" leads them to expect that the personal efficiency of workers alone can accomplish the desired results. Too often when there is a shortage of output or falling behind of production programs, the salvation is sought in the so-called "shock brigades," and not in the strengthening of the mode of management. These "shock brigades" are composed of volunteer workers pledging themselves to increase the production by all means within their power. They do, at least temporarily, a measure of good. By their enthusiasm and example they often improve the shop morale, reduce tardiness and absenteeism, make steady work during the shift socially respectable, provide stimuli for reduced spoilage, lower expense, and promote general economy; but they cannot and they do not bring order out of chaos. As a matter of fact, an efficient "shock brigade" frequently so outstrips the rest of the workers that the management without the aid of proper dispatching, scheduling, and control of the flow of production, finds itself facing an utterly unbalanced inventory of finished and semi-finished parts, with operating capital tied up and with the actual output but slightly improved.

It is difficult for those in America to realize fully the managerial handicaps so characteristic of the giant infant—Russian Industry. We hardly ever stop to consider what a predominant proportion of our industrial activities is carried by the established standard of procedure; how much specialized knowledge is available for the asking from a supply firm, sales engineer, or a foreman or superintendent with a vast experience elsewhere, and even from a competitive firm. We are in the habit of dividing the operating problems into two great classes: *routine* and *exceptions*. Under the first class fall all functions that are well standardized either by tradition or by analysis, all of these being handled by clerks and various supervisors. Under the second class we place all the unusual and emergency occurrences which fall under the jurisdiction of specialists or executives. They are relieved of all routine work, but as soon as production gets out of balance, supply is disrupted, personnel demoralized, distribution crippled, expenses and prices take a swing, or a new line of production is contemplated, these executives step in, mind-free from all the normal operating details which are left to the standardized functions of the routine men.

There is no such clear division of responsibilities in Russia. We read time and again in local papers, and ourselves have observed that in the plants managers having no information to rely upon and to be guided by, instead of taking their time and studying such methods, waste their time by walking miles and miles daily through the vast shops hoping mostly in vain, to find on these sightseeing tours some important items requiring their executive attention.

This absence, or near-absence, of an established routine of standardized procedure is of course a normal thing in a young industry grown almost overnight and having no past on which to base useful traditions. Nevertheless, the harm and waste resulting from this lack of functionalized division of responsibilities is very great; but the chances are that it soon will be in disrepute.

There is no doubt that Russians can learn things quickly. A group of Japanese undertook to teach them how to organize locomotive repair work with the result that what used to take weeks now is being done in a few days. We Americans showed them how to quadruple their machine-shop output without adding equipment or changing the design of the product, merely by getting the flow of work under control with the aid of Gantt charts and other purely managerial means. They begin to realize the importance of this transfer of skill. For instance, an American textile engineer was engaged to prepare a full set of standard practise instructions for the headquarters responsible for the organization of the textile industry.

All of us are familiar with that naive emotion which may be termed "the lure of the machine," that admiration of its almost intelligent working, that awe of its superhuman power, and that great expectation of the beneficial results to be derived from it. We learn, however, that the machines are a liability, not an asset, until brains are employed to organize their utilization. A million dollar plant producing $600,000 work of goods, if operated at half its capacity, causes $130,000 annual loss. Assume now that there is the demand for double the output. It can be secured by two means: double the plant at an investment of another $1,000,000 and increase the payroll by another $100,000, or else utilize the existing plant with double efficiency by means of modern managerial technique. Are such services worth, say, half of the $130,000 a year previously wasted because of the absence of such specialized skill, or is it more economical to incur an added obligation of $300,000 for the physical extension of the plant capacity under the old management?

Naturally, the European manufacturers seeking a market for their machinery in the rapidly growing U.S.S.R. are advocating the second method of new investments, suggesting at the same time that their unemployed technicians may go to Russia and transfer their skill, no longer needed at home, to demonstrate the operation of the important equipment for a compensation commensurate with the depressed hope of finding a job at home.

THE PROBLEM

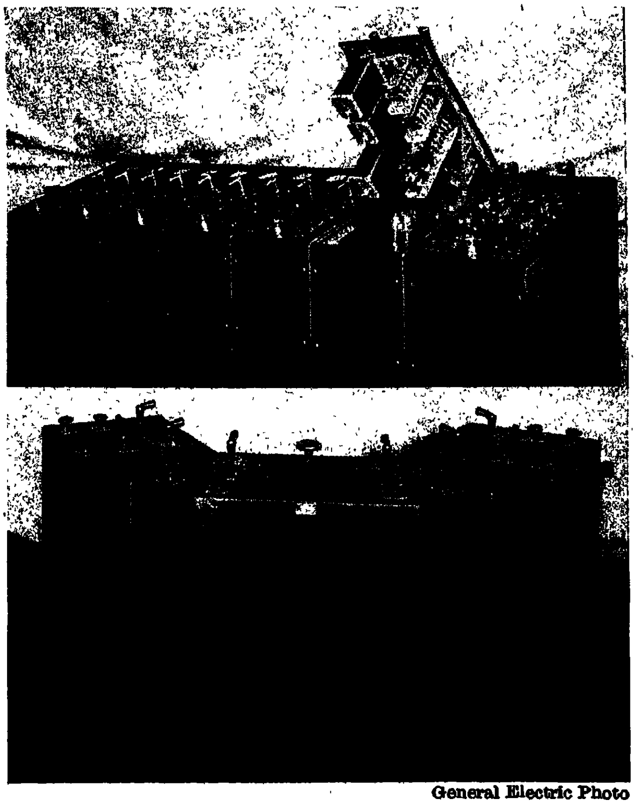
And then what? Mines are mechanized, new plants erected and equipped, factories rejuvenated by the new machinery, *but* the degree of their utilization, due to old fashioned organization, lack of administrative experience, and absence of management technique and executive training remain nearly as low, if not lower, than before the enlargement due to the dilution of the executive and managerial forces by the as yet inexperienced newcomers placed in charge of new plants and extensions.

Such seems to be the main problem confronting the fulfilment of the Russian "Five Year in Four Plan" today and its future destiny. There is an alternative: either to burden the country with an additional mass of the means of production for generations inadequately utilized, or to transfer the managerial skill, to accelerate the period of learning and, in the words of one of the vice presidents of the Supreme Economic Council of U.S.S.R., to get rid of that "ugly, oriental expectation of miracles from new machinery."

In the light of our American experience, especially since the days of Gantt, and in view of the European seeking of advice of American management engineers, it appears as a foregone conclusion that the U.S.S.R. must and will follow both roads. First she must build up the industry with essential equipment; but next, if she does not want to ruin the equipment by poor attendance, and if she wants to obtain full results from the investment made, she should definitely commit herself to the transfer of managerial skill on a par with the importation of machinery.

Upon this decision apparently rests the answer as to how well Russia will fulfil her Five Year production program.

Compact Industrial Control



General Electric Photo

SOME of the trends in industrial electrical control as exemplified by recent steel mill installations are indicated in the accompanying illustrations. A seven-panel control desk built for use in connection with a 65-panel switchboard may be seen in the upper illustration. This board although only 98 in. long, and 30 in. high in front, accommodates full control for nine large d-c. motors and five d-c. generators, motor controls including reverse, and fine and coarse speed adjustments.

Unity Power Factor For Neon Tube Signs

Application of parallel capacitance will not correct the power factor of the usual commercial neon tube installation to a value greater than 90 per cent. A constant-current circuit for use with these signs is described in this article, which not only operates at unity power factor but possesses other advantages.

By
J. K. McNEELY
Fellow A. I. E. E.

R. R. LAW
Associate A. I. E. E.

Both of Iowa
State College, Ames

ATTEMPTS to correct the power factor of neon tube electric signs by the use of parallel capacitance have not been altogether successful. Although sufficient capacitance can be added to shift the apparent phase position of the current wave to the phase position of the voltage wave, this will not provide for unity power factor because of the non-sinusoidal nature of the current wave. While in most cases power factor correction for this type of equipment cannot be justified from the cost standpoint, nevertheless the circuit described here does provide power supply at unity power factor and without presenting any additional difficulties either of an economic or engineering nature.

OPERATING CHARACTERISTICS OF PRESENT EQUIPMENT

Since the resistance of a gaseous conductor tube is practically in inverse ratio to the current flowing through it, in order to limit the current its power supply must be received through a high series impedance. This impedance must of necessity be essentially reactance, as a direct power loss would result if resistance were used for this purpose. In the past this higher reactance has been obtained most economically by using a supply transformer with abnormally high leakage reactance. (See Fig. 1.). Low power factor results from the use of transformers of this character, being usually of the order of from 30 to 40 per cent.

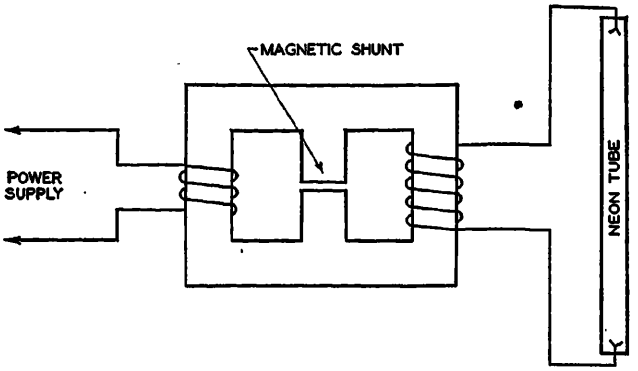


Fig. 1. Schematic diagram of ordinary neon tube installation with high-leakage-reactance transformer

When these high-leakage transformers are connected to lines having sinusoidal voltage waves, a current wave of non-sinusoidal form will flow as indicated in Fig. 2. The current wave in this particular case lags the voltage wave by about 72 degrees (31-per cent power factor) and was found to contain both third and fifth harmonics of appreciable magnitude. If capacity reactance be paralleled with the transformer primary in an effort to improve the power factor, the optimum power factor will be obtained when the fundamental component of the current wave is in phase with the impressed sinusoidal voltage wave. Under these conditions the harmonic components of the current wave will remain unaltered since with a sinusoidal impressed voltage, capacitance can draw only current possessing a sinusoidal wave. For this reason the best power factor which can be obtained in this manner is only from 80 to 90 per cent.

CONSTANT-CURRENT CIRCUIT

A number of constant-current circuits have been developed from time to time in the past, especially for application to arc-light service. One such circuit as described by Steinmetz in his "Theory and Calculation of Electric Circuits," has been adapted for neon tube operation. This is shown schematically in Fig. 3.

With this arrangement, current supplied to the transformer primary by the constant-current circuit will at all times bear a constant numerical relation to the impressed voltage regardless of the transformer impedance. Thus the high impedance of the transformer on no-load during the start of each half-cycle and before the breakdown of the neon tube load on the secondary will give secondary voltages of sufficient magnitude to induce ionization in the neon tube, if the transformer turn ratio be appropriate. As soon as secondary breakdown has been effected, the impedance of the transformer drops lowering the transformer primary voltage required to maintain the current to the point where the primary voltage times the turn ratio equals the secondary voltage required to sustain current flow in the neon tube.

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

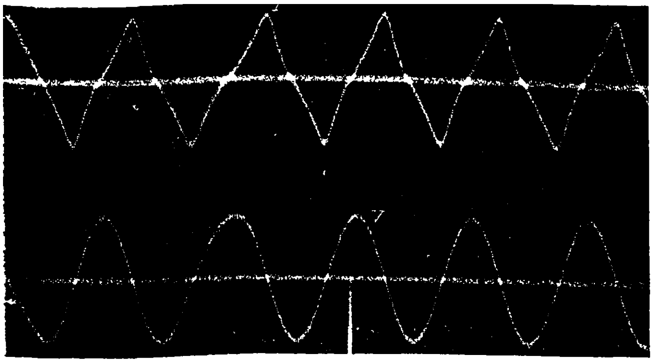


Fig. 2. Current (I) and voltage (V) waves for typical neon tube installation such as shown in Fig. 1

The oscillogram shown in Fig. 4 shows the current wave as taken from the line by this circuit with a sinusoidal impressed voltage. The current wave also is of sinusoidal form and is in phase with the voltage.

ADVANTAGES OF CONSTANT-CURRENT APPARATUS

A series of comparative tests were made to show the relative advantages of the constant-current circuit as compared to those of the high-leakage transformers now being used. In these tests the light output of the neon tube was determined by means of a photoelectric cell placed adjacent to the tube. A microammeter and a 90-volt battery were connected in series with the cell. The microammeter indications thus gave a measure of the light output of the tube. Since only comparative results were desired, the readings were used directly without conversion into equivalent light output.

Results of this series of tests are given in the accompanying tabulation. It may be noted that the proposed constant-current circuit gives a ratio of light output to watts input midway between those obtained from the two commercial transformers tested. Also the capacity reactance required to bring about the best power factor is lower for the constant-current circuit than for the standard commercial transformer circuits. Unity power factor was attained readily with the constant-current circuit while for the corrected standard commercial transformers the best obtainable was not over 90 per cent.

COST COMPARISONS

Although no accurate data are available showing the relative costs between inductive and capacity reactances for service demands such as those involved in this application, a careful estimate shows that the reactances used in the proposed circuit should cost somewhat less than the parallel capacity reactance required to furnish the maximum correction for a commercial type, high-leakage-reactance transformer.

The constant-current circuit requires less current in its transformer primary winding than does the corrected

Comparison Between Constant-Current Circuit and High-Leakage-Reactance Transformers

Item	Constant-Current Circuit	Commercial Transformer No. 1	Commercial Transformer No. 2
Minimum primary current, amperes (r. m. s.)	0.265	0.350	0.354
Power factor, uncorrected	1.000	0.319	0.312
Best power factor obtainable	1.000	0.908	0.808
Capacity reactance required, μf	12.45	21.40	19.20
Power in watts	30.40	36.23	32.45
Secondary current, milliamperes	15.00	15.00	16.10
Secondary milliamperes per watt input	0.493	0.413	0.496
*Photoelectric current, microamperes	9.90	9.90	11.10
Photoelectric current/watts input	0.326	0.272	0.342
Same as above, with maximum power factor correction	0.326	0.286	0.359
Photoelectric current/amperes line current	37.30	38.30	31.30
Same as above, with maximum power factor correction	37.30	10.30	12.50

*These readings not translated into equivalent light output since comparative results only were desired.

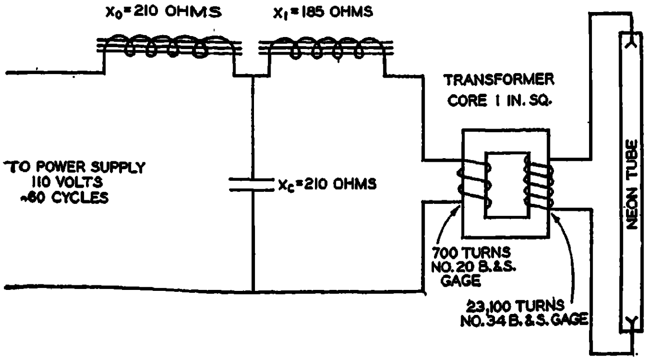

X₀=210 OHMS
X₁=185 OHMS
TRANSFORMER CORE 1 IN. SQ.
TO POWER SUPPLY 110 VOLTS ~60 CYCLES
X_C=210 OHMS
700 TURNS NO. 20 B.&S. GAGE
23,100 TURNS NO. 34 B.&S. GAGE
NEON TUBE

Fig. 3. Constant-current circuit for supplying neon tubing at unity power factor; constants used in the experimental set-up are shown

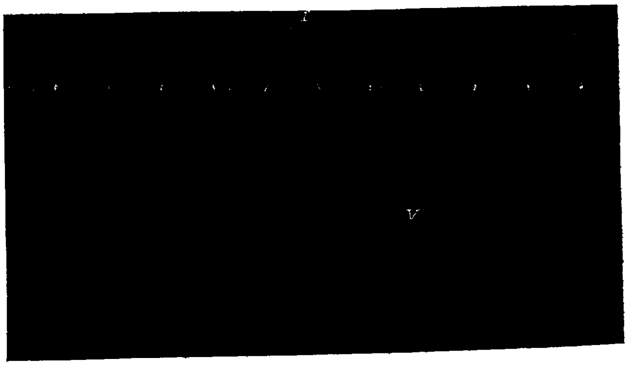


Fig. 4. Current (I) and voltage (V) waves for constant-current circuit of Fig. 3. Note "in-phase" sine-wave current

or uncorrected magnetic-shunt type of transformer now in use. Thus a smaller size of wire may be used in the primary circuit of the transformer used in the constant-current circuit with a corresponding additional saving in cost.

In addition to the advantages already mentioned, it is necessary to mount only the transformer of the constant-current circuit on the neon tube sign itself; the reactances may be mounted inside of the building. The constant-current transformer has the further advantage of requiring less space than the magnetic-shunt type.

As stated at the outset, the general use of corrective circuits or other means of raising the power factor of gaseous conductor lamps cannot be justified in most cases from the standpoint of economy. However, the solution presented here corrects some of the defects or errors of the earlier solutions without presenting additional difficulties either of an economic or engineering nature.

Operating Experiences with Automatic and Supervisory Control

Records have been kept by three different investigators on various types of automatic equipment for station control. These results are summarized in the following articles.

PROGRESS in the development of automatic equipment and in its application to the control of electrical energy has followed very closely the phenomenal growth of the industry itself during the last decade. Automatic equipment was applied first to the control of small outlying transformer stations. As the success of these installations was established and new control schemes and devices were developed, the application has been extended to include practically all types of stations. The chief reasons for this wide popularity are that the first cost of the station is increased but little while reliability and flexibility are as good if not better than with an attended station, and operating costs are materially less.

In the group of three articles following, the experiences of several years' operation on different types of equipment for automatic and supervisory control of railway substations, a-c. distribution substations, and generating stations are presented. The authors of each article have given a summary of records on their equipment, kept over a period of years and presenting principally the operating troubles most frequently experienced.

Automatic Control of Substations

By
GARLAND STAMPER
Associate A. I. E. E.
Columbia Engg. & Management Corp., Cincinnati, Ohio

AUTOMATIC and semi-automatic stations of various types have been in operation during the past ten years on the system of the Columbia Gas and Electric Corporation. These stations include transformer substations for distribution at both 13,200 and 4,325 volts, street railway and Edison system synchronous converter stations, and synchronous condenser installations.

The distribution substations have been equipped with automatic reclosing oil circuit breakers and automatic induction voltage regulators on the feeders, with load-response equipment included in the transformer bank control. The street railway converter stations and two Edison system motor-generator sets are completely automatic in operation. The control of the converters is designed to function on voltage variation

---

From "Operating Experiences with Automatic Stations, Part I—Columbia Engineering and Management Corporation" (No. 31-94) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

and load demand, and includes many other features incorporated in the latest designs for this class of equipment; the circuit breakers on the d-c. feeders open on rate of rise of current and reclose when the circuit is clear. The synchronous condensers and all Edison system synchronous converters are equipped with semiautomatic control. This scheme includes complete starting operation when initiated by the operator, voltage regulation, load-limiting devices and other protective functions. The operation of any protective device in an automatic station transmits a signal to the office of the system load dispatcher.

It is realized that the class of service secured from any type of automatic station is dependent directly upon the excellence of inspection and maintenance. In the Cincinnati district there are five automatic-station operators, carefully selected and trained; their duties include the inspection and maintenance of fourteen stations. An effort is made to have an operator visit the more important stations once a day and the smaller stations two to three times a week for a regular inspection. This inspection consists of making the necessary meter and operation counter readings, adjusting graphic meters and changing the charts, adjusting battery-charging equipment, checking temperatures and general operating condition of all apparatus, checking indicating lamps, fuses, and grounds on control circuits, and in the case of rotating equipment observing the starting and stopping sequence. Once each week the rotating apparatus and all of its control equipment is cleaned and if necessary repaired, and a complete check is made of the proper functioning of all devices. Once every two weeks the equipment on each reclosing feeder is given the same general overhauling. Once each week all the control batteries are given a slight change and their condition checked. Finally, twice a year all the apparatus in the station is given a complete overhauling by the regular maintenance crew under the supervision of the automatic substation operators.

Upon looking back over the operating records of the distribution stations it is noted that at least 90 per cent of the faults on a circuit are temporary in nature and that the breakers remain closed after the first or second operation. These circuits having automatic reclosing circuit breakers are equipped with instantaneous overcurrent relays set to operate at a predetermined value of current which is slightly below the safe rupturing capacity of the circuit breaker, or the thermal capacity of the regulators. The operation of these relays prevents the reclosing of the circuit breaker until the fault has been cleared and the relays reset. To date there has been only one operation of these relays, which was caused by a cable failure near the station. By the use of such relays it is considered safe to install equipment having lower capacity, or to make the time between circuit-breaker reclosings less than otherwise advisable.

On the system of the Dayton Power and Light Company several automatic distribution stations are in operation. These stations are of the outdoor type having reclosing circuit breakers equipped with a-c. motor-operated closing mechanisms and 24-volt d-c. trip coils. So much trouble has been experienced with this type of control that except for special cases no similar equipment is being considered for future installation. The auxiliary switches are a source of perpetual annoyance and the centrifugal closing mechanism has a tendency to lose its adjustment and cause the breaker to "pump," or else fail to close altogether. It has been decided that future installations of this nature will include solenoid-operated breakers with a control battery, or some similar source of supply. Since the cost of the solenoid mechanism is less than the motor mechanism, this compensates to some extent for the additional cost of the control battery.

One of these stations was supplied through a tap connection on the double-circuit 33,000-volt loop around the city. Approximately two years ago this station was rehabilitated and 33,000-volt sectionalizing equipment was installed. At this time the control scheme was changed from automatic to supervisory, and is operated from the dispatcher's office approximately four miles distant from the station. The only source of trouble experienced on the installation to date has been due to interference by the telephone company from which the interconnecting wires are leased. Another point of some interest in this station as well as in automatic stations in general is the use of diverter-pole-type motor-generator sets for control battery charging. In case of complete outage of the station it was found that this set could be started automatically and reconnected to the battery without super-

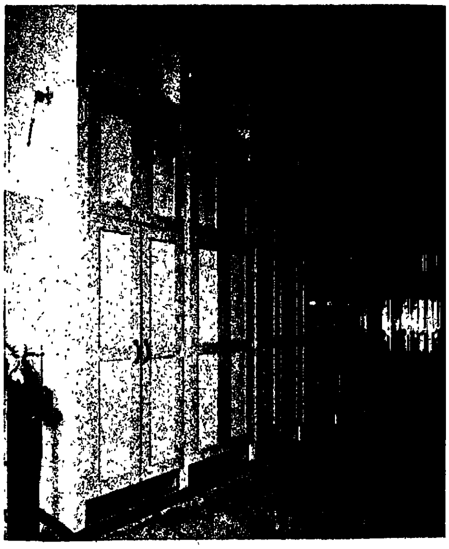


Fig. 1. Typical regulator structure showing installation of Lux fire extinguisher

vision. It is the practise at all times to float the motor-generator set across the battery.

In addition to the above stations this company has been operating four automatic street railway converter substations for approximately ten years. A great deal of trouble was experienced with these installations due principally to the use of the old plunger and bellows types of relays. These were not as accurate or reliable as the present induction relays and motor-operated timers. Practically all the original relays have been replaced by relays of later design and very little trouble from this source is anticipated in the future.

Listed in the order of frequency of occurrence, the chief items of trouble experienced in these automatic stations are: (1) improper adjustment of graphic meter pens and clocks, (2) loss of adjustment of circuit breaker auxiliary switches and closing mechanisms; (3) grounds on control circuits; and (4) relay troubles due to obsolescence and loss of adjustment.

It is to be concluded from the results of these experiences that when properly operated, the automatic station is equal to and in some respects superior to attended stations in reliability and flexibility. On the whole it is found that automatic equipment will perform the necessary functions more accurately and faster than could be expected of any operator. This results in an improvement in continuity of service by decreasing outage time, thus increasing revenues as well as good-will. At the same time, the duties of the system load dispatcher are lightened, permitting him to give his attention to the more important matters in times of major system disturbances, with a resultant increase in total system efficiency.

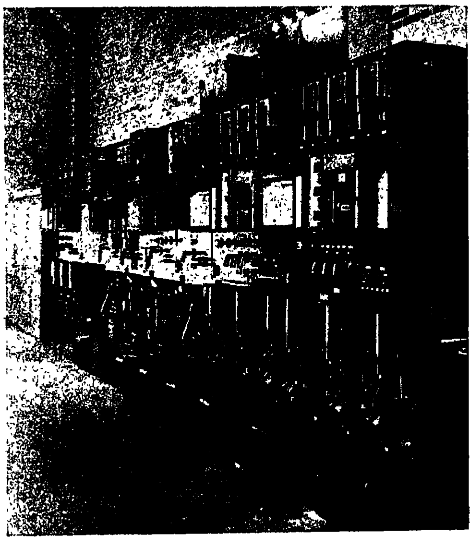


Fig. 2. 4,325-volt metal-clad switchgear showing mounting of relay and control equipment

Automatic and Supervisory Control of Substations

By
F. F. AMBUHL
Associate A. I. E. E.

Toronto Hydro-Electric
System, Toronto, Ont.

THE POLICY of the Toronto Hydro-Electric System is to locate moderate-sized distribution stations near the economical load centers and equip them for automatic or supervisory control. These automatic and supervisory equipments include all the more prominent types as well as equipment developed by the Toronto system for its own use. In addition there is at present a Gamewell signaling system which is used for giving signals to the load dispatchers when switches open automatically in small unattended transformer stations where supervisory control has not been provided.

The automatic control for synchronous converter stations is arranged to start the converter on load demand determined by a contact-making voltmeter, and to shut down the unit when the load is reduced to an economical point. Two schemes are used on the Toronto system for accomplishing this result; the General Electric scheme in which a drum controller initiates the various operations in proper sequence, and the Westinghouse scheme in which these steps take place through the guidance and control of relays and interlocks functioning according to a predetermined plan in a step-by-step fashion. Both types of equipment have given satisfactory operation for over nine years, although a few troubles have been experienced. The principal difficulties with General Electric equipment are as follows:

1. When first installed the timing relays gave trouble and had to be replaced.
2. The field relay did not function properly, and required a new coil.
3. Some trouble has been experienced with the brake-bands on the brush-lifting mechanism, making replacement necessary.
4. An open circuit in the exciter generator used for correcting polarity occasioned considerable operating difficulty before it was known that this was the trouble.

With the Westinghouse scheme most of the troubles occurred during the first year, and since their elimination the equipment has given very satisfactory operation. The troubles were as follows:

1. The latching relay on the oil switch required modification.
2. Trouble was experienced with the contacts of the auxiliary switches controlling the main contactors, making it necessary to modify these devices.

From "Operating Experiences with Automatic Stations, Part II—Toronto Hydro-Electric System" (N . 31-94) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

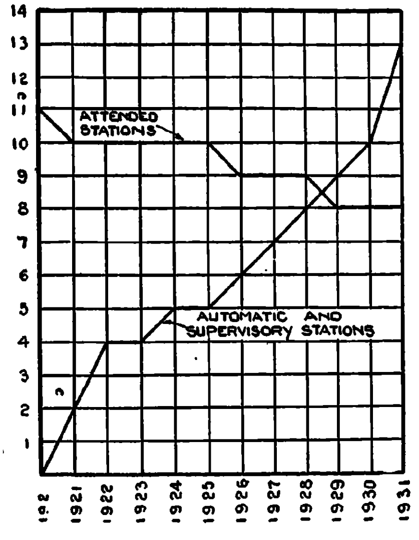


Fig. 3. Number of supervisory and automatic stations compared with attended stations

3. The contactor coils burned out repeatedly, and finally were rewound with a larger number of turns to avoid overheating.

4. Converter-bearing thermostats became inoperative due to warping of the fiber plunger rods.

5. The brush-lifting motor burned out, requiring replacement.

6. The brush-lifting mechanism gave considerable trouble, and had to be modified.

7. N little trouble was experienced with the arcing over of contacts on the polarized motor relay. These contacts had to be modified before the trouble was eliminated.

The two 1,100-kw. mercury-arc rectifiers manufactured by the Brown Boveri Company are fully automatic, the automatic features including (a) plant control whereby either unit may be made the leading unit while the other is switched in or out according to the demand on the station; (b) a-c. closing and reclosing whereby the circuit breaker connecting the rectifier transformer to the a-c. supply is controlled; (c) vacuum-pump control; and (d) the protective group. This rectifier equipment has given very satisfactory operation although some operating troubles were experienced when the apparatus was first installed. These were:

1. Insulator on excitation anode was found cracked due to incorrect size and improper packing.

2. Ignition coils burned out several times due to relay sticking, but this was overcome by modifying the relay.

3. Poor contact on control relay prevented the rectifier from being cut in.

4. Trouble on overload relay contacts prevented the second unit from coming in.

SUPERVISORY CONTROL EQUIPMENT

The Westinghouse high-speed, visual, supervisory-control system is an all-relay system embodying the principle of step-by-step synchronous selection. This system has been installed in four stations, the first having been installed six years ago, the second four years ago, and the other two, three years ago. This equipment although not entirely free from trouble has given satisfactory operation. In almost every instance, however, the troubles experienced are of minor nature, and usually are found to be due to contacts or relays requiring slight readjustment. Control-key contacts, battery equipment, and fuse troubles also contribute to faulty operation.

In the Danforth station 45 cases of relay troubles were reported in five years. Fourteen of these were due to latching relays sticking. Operating records of the other stations using the same kind of equipment, but of more recent date, do not show the latching relays to have given any more trouble than other relays.

The distributor-type supervisory-control system of the General Electric Company was installed in the Parkdale station in 1928. This was one of the early developments of supervisory control and uses a modification of the printing telegraph distributor and polarized relays to minimize the number of connecting line wires between stations. Due almost entirely to the distributor mechanism considerable trouble was experienced with this type of equipment.

The motor-driven distributors, one installed at each end of the control system, were operated continuously and had to be kept in synchronism if proper operation of the control system was to be obtained. Numerous faulty operations were experienced as a result of this part of the equipment getting out of order, and it was finally decided to change the system to the more recent development known as the synchronous-selector type of supervisory control. This new system, which replaced the distributor-type supervisory control in the Parkdale station, is essentially a direct system of control and indication employing the familiar type of rotary selector used for automatic telephones, which step in synchronism to transfer the control and indication line-wires from one circuit to another as selected by the dispatcher. This synchronous-selector type of equipment has been in operation since April 1930, and has given very satisfactory operation. Only two relay troubles have been experienced during the first eight months.

A cable system of supervisory control which was developed by the Toronto system for its own use is

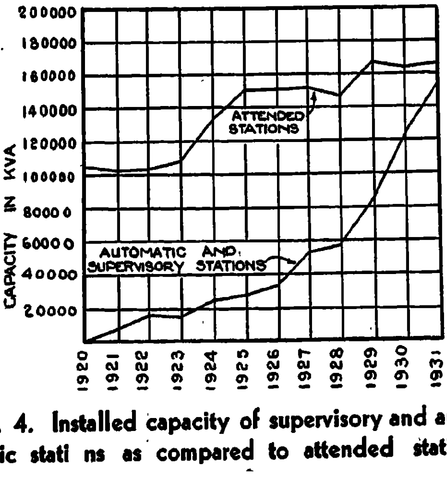


Fig. 4. Installed capacity of supervisory and automatic stations as compared to attended stations

Table I—Performance of Supervisory Equipment

Station	Type	Control positions	Months in service	Supervisory relay trouble	Control key trouble	Battery equipment trouble	Fuse trouble	Human factor	Line troubles	Outages due to supervisory trouble	No. of operations per year
Market	T.H.E.S.	30	114	4	4	2	5	1	None	1	100
Keele St.	T.H.E.S.	17	102	3	2	2	1		1	1	175
Carlaw	T.H.E.S.	18	11	5	2	2	2		None	0	400
Danforth	W.E.&M. Co	50	60	45	2	5	2	3	None	8	3,000
Parkdale A	G.E.Co.	46	21	7* 98†	4	1		3	None	11	300
Parkdale B	G.E.Co.	46	8	2	0	1		2	None	2	325
Defoe	W.E.&M. Co	30	53	9	1	2	1	2	None	8	175
John St	T.H.E.S.	30	18	2	1		1	3	1	1	100
Wiltshire A	W.E.M.Co.	40	47	10	3		3	0	None	8	2,000
Wiltshire B	W.E.M.Co.	40	47	10	4	4	2	0	None	4	200

*Relays †Distributor

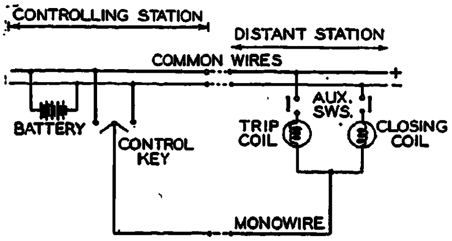


Fig. 5. Fundamental circuit of Monowire supervisory control scheme

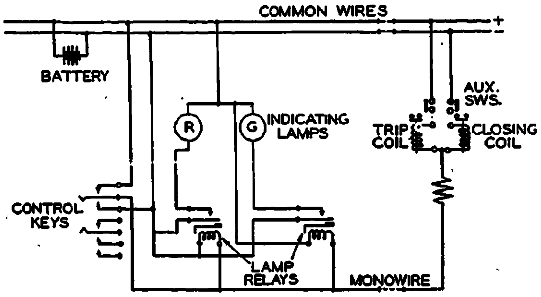


Fig. 6. Monowire scheme with indicating features

installed for four stations. It has been called the Monowire type of supervisory control, since in addition to two wires which are common to all control units it requires only one wire for each unit to be controlled. Control of the units and an indication of their operation can be secured by this system, simplified diagrams of which are given in Figs. 5 and 6. In complete commercial circuits, additional lines and safety features are added. Although the diagrams show control for one unit only the scheme may be extended to any number of units desired.

During the past ten years this system of control has given very satisfactory operation. There has been very little trouble with the switch operation, although a certain amount has been experienced with the signal devices. Most of the trouble was due to faulty relay operation. The relays used in this system are standard and have been tested under most severe operating conditions. Troubles have been due to a number of causes, such as residual adjustments, faulty contacts, loose nuts and screws, dirt, etc., all of a minor nature. A few sources of trouble have occurred with control-key contacts, battery equipment, poorly soldered joints, loose fuses, blown fuses, etc. Relay equipment purchased recently has given much less trouble than the earlier equipment, indicating that the manufacturers have overcome troubles experienced with the earlier designs.

This cable supervisory system finds its widest application where the distance between stations is short. The very satisfactory operation secured with this scheme has resulted in its being used on the Toronto system where the total cost of installation, including supervisory cables, was less than other schemes using synchronized switches at the sending and receiving ends. It is so much more simple and reliable than the other systems that its use seems justified wherever cost will permit.

Supervisory Automatic Control of a Generating Station

By
R. M. STANLEY
Fellow A. I. E. E.
Byllesby Engg. & Management Corp., Chicago

EIGHT hydroelectric units, each having a capacity of 13,508 hp., are installed in the Ohio Falls hydroelectric station at Louisville, Ky. Each generating unit is complete in itself. Waterwheel, generator, exciter, governor, electrical control, oil and water supply, oil circuit breakers, etc., are individual to each

---

From "Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control" (No. 31-109) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

unit and all related unit auxiliaries are fed entirely from that unit.

An automatic electrical control unit and a hydraulic control unit are located near each generator. The electrical control equipment is similar to that used in other stations but is placed inside of a sheet steel cubicle located adjacent to the governor. For all units in the station, there is a centralized supervisory control switchboard of the miniature type located near the center of the plant, with a multi-conductor telephone cable between the miniature board and each generator control unit. The miniature supervisory board resembles in some respects a manually operated telephone switchboard. The arrangement of control keys and indicating instruments on 4-in. panels places the control of all generators, transformer banks, etc., within convenient reach of the operator.

The advantages of supervisory and automatic control have been demonstrated clearly during their three years of operation. With the miniature switchboard, the operator is at all times closer to indicating instruments, control switches, etc., and can give better and closer supervision to the operation of the equipment. This results in better voltage control, frequency control and division of load among the generating units. The supervisory control and automatic features give another distinct advantage in that there is a great saving in time during normal and emergency operation, and to a large extent human error is controlled. When urgently needed a hydroelectric unit can be brought to speed and synchronized in one minute, and additional units can be put on the bus in approximately 30-sec. intervals thereafter. Due to this speed, it has become the practise to carry less reserve steam capacity when hydro units are available.

There is a marked saving in labor costs since only one shift operator is required for the entire station. In addition, supervisory and automatic control made it possible to reduce the initial capital expenditure and to lower fixed charges.

The miniature board is no more costly to maintain than any other type of switchboard; in fact, a comparison with maintenance costs on a benchboard and vertical board with full-sized instruments, control switches, etc., at Waterside steam station indicates that the maintenance and inspection cost of the miniature switchboard and automatic equipment is less. As most of the equipment is enclosed in a practically dust-proof cabinet very little cleaning has to be done.

SCHEME OF CONTROL

The general scheme of control is that the turning of a miniature control key or pushing of a button at the miniature supervisory board sets in operation automatic relays associated with the unit being supervised. These automatic relays, of the polarized type, function in a predetermined sequence for each desired operation, such as the starting or stopping of a generator, or connection of a transformer bank. A remote indication of the kilowatt load, reactive voltamperes, and voltage on each unit is given on miniature instruments. For the generators these are direct-connected to the instrument transformers, and on transformer banks, Selsyn type miniature instruments are used.

On starting a generating unit the supervisory operator turns a key which selects the proper bus and synchronizing method. He then pushes a button which gives the starting impulse to perform the following functions: maintain governor oil pressure; release brakes; open gates; apply generator field; energize governor motor from generator supply; start generator air-cooling system; and synchronize the generator to the bus selected. The supervisory operator may then regulate the load, voltage, and reactive voltamperes.

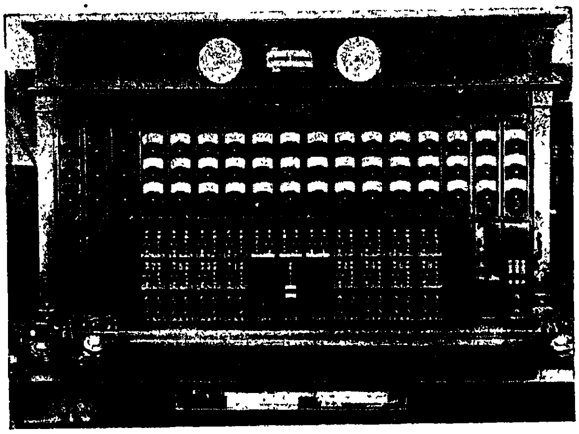


Fig. 7. Miniature switchboard for supervisory control of all generating units in station

While in operation a full set of protective equipment is in use, and when the operator desires to shut down a unit the procedure is somewhat similar to that of starting. The equipment is tested only at intervals of three or four months when it appears necessary to clean the equipment.

Over a period of three years there have been no failures in the supervisory cable conductors. The push-button for control of load and voltage are similar in construction to telephone jacks, and have given very little trouble. A few cases of trouble were experienced with the rotating type keys used for giving the starting impulse, for selecting the proper bus and method of synchronizing, and for opening or closing oil circuit breakers. These troubles were all traced to insufficient spring tension, and no failures have occurred since proper adjustment. There has been only one unusual case of trouble with the polarized relays energized from the keys on the miniature board. This developed in summer when the relays were subjected to an ambient temperature of 50 deg. cent. and the impregnating compound in the coils tended to vaporize and deposit on the armature, causing sticking in one position. This type of coil was changed and no further trouble was experienced. No cases of trouble have occurred with the sturdier contactors used for voltage and load control.

With the generator protective equipment very few difficulties have occurred. Practically all of these which could be attributed to manufacturing defects resulted because of vibration.

SYNCHRONIZING METHODS

Generators may be synchronized to the bus by two methods; (1) through self-synchronizing equipment wherein the machine is brought up to speed, the armature is closed in on the bus, and the field applied instantly thereafter; (2) automatic synchronizing relays which approximate closely the manual method of synchronizing. The speed of the incoming machine is regulated to match that of the running machine and when the phase-angle between the voltage of the two machines is satisfactory, the machine is closed in on the bus.

Each method has its advantages. The self-synchronizing method is faster, requiring about one minute to bring a machine up to speed and synchronize; this is generally used when the system capacity is large and the head of the river is above 20 ft. Oscillograms taken during synchronizing indicate that the current in the armature varies from one and one-half to twice normal. This dies down rapidly and generally reaches normal value in ten cycles. At the Waterside steam station a slight dip in system voltage equivalent to about one volt on a 110-volt basis occurs. The "bump" given the system during these conditions therefore is found to be not objectionable and the self-synchronizing method is used whenever possible. It has a further advantage over automatic synchronizing in that it enables a generator to be pulled into step during periods of severe system trouble when the frequency is below normal. The automatic synchronizing equipment is used only when the output of the hydro station is small due to the low head. The majority of synchronizing operations with this equipment require from two to three minutes from the time the unit is started; but very exact synchronizing results.

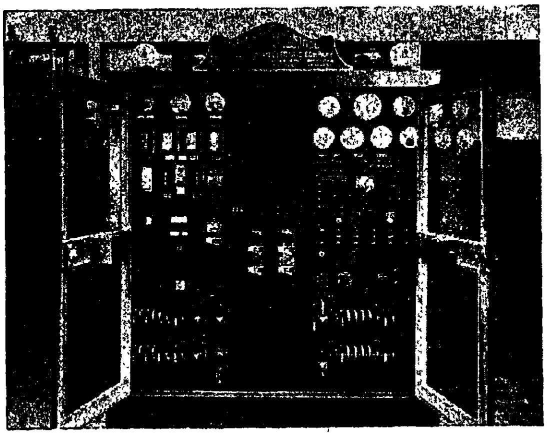


Fig. 8. Individual generating unit switchboard

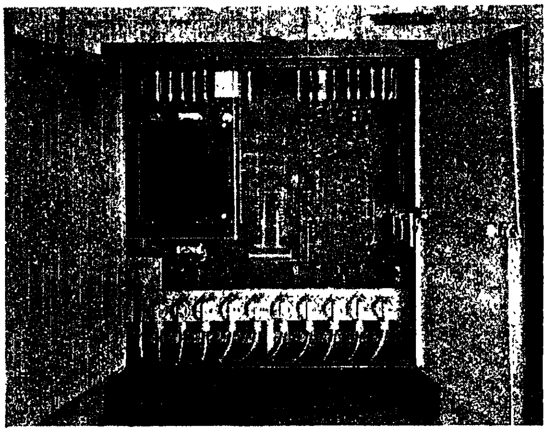


Fig. 9. Rear view of generator switchboard

To date there have been five system disturbances which resulted in the hydro station dropping load. These disturbances all occurred before the generators were equipped with self-synchronizing equipment; therefore, in cases where the automatic synchronizing equipment did not function rapidly enough, the operator put the machine on manually in order to save time. A maximum of four minutes was required to get the last generator on the bus. Now that the much quicker method of self-synchronizing is installed for all generators, it is being used almost entirely.

Each disturbance was caused by a short circuit of considerable magnitude, and when the circuit breakers opened, the overspeed of the generators and consequent rise of voltage was sufficient to operate the overvoltage protective relays, thus removing the generators from the bus and shutting the units down.

The operating experience obtained with the supervisory and automatic control at this station during the past three years indicates definitely the advantages of this combined system. The use of automatic devices has demonstrated its reliability, low cost of maintenance and inspection, the saving of time and operating expense, and the ease of supervision and operation. It is believed that in hydro plants where units are taken off and put on the bus frequently, this type of control equipment not only is superior to manually operated equipment, but that the plant will be operated with greater safety to equipment.

Communication in the New Waldorf Astoria

Said to be the most completely equipped hotel ever built, this new edition of a famous old hostelry contains the largest array of electrical program distribution equipment ever installed in one building. Included also in its communication system are approximately 3,700 telephones and 66 teletypewriters; 125 trunk lines connect the hotel with the telephone central office.

THE LARGEST program distribution and public address system so far brought together under one roof has been installed in the new Waldorf Astoria Hotel, recently opened in New York. Six separate channels are provided over which six different entertainment features may be distributed simultaneously both to the 1,940 private rooms and also to the many public rooms. This hotel occupies an entire block in the heart of the city and has a total height of 640 ft., including the 42 floors, and the two 100-ft. towers. It is considered to be the most completely equipped and most modern hotel yet constructed.

In addition to the program distribution facilities, the Bell system has arranged a communication installation which is said to be the most extensive ever placed into service in any hotel. Two groups of telephones have been installed, one to serve principally the hotel guests, the other to be used by the management for administrative purposes. To supplement the facilities for transmitting the spoken word, the hotel has been equipped with 66 teletypewriters. The entire communication system is served by 125 trunk lines from the telephone central office.

PROGRAM DISTRIBUTION SYSTEM

Features to be distributed over the six channels of the program distribution system may originate from any of the following sources:

1. Programs picked up by standard condenser microphones in any of the various public rooms.
2. Radio programs picked up by any of six Western Electric 10-A radio receivers.
3. Recorded programs reproduced on double turntable reproducer sets, of which two have been provided.
4. Wire line programs brought in from the outside.

A schematic diagram of the complete system may be seen in Fig. 1, all of the apparatus shown being housed in a control room on the sixth floor of the building. On the left may be noted the various program sources. Immediately to the right of these may be seen a bank of three-channel "mixers" and speech amplifiers. By means of these the input from as many as six microphones at one location may be blended together and amplified before going to the main amplifiers. Circuits are provided whereby the operator in the control room can communicate with an "observer" in any public room in which a program may originate.

For the six main amplifiers, one for each channel, Western Electric type 59-B units are used with the usual volume indicator, monitoring headset, and switching controls. The amplifiers operate entirely on alternating current, and possess practically a flat frequency characteristic between 20 and 10,000 cycles.

The power amplifiers consist of 31 Western Electric type 57-A units, 24 of which are used for guest room service, six for the public room circuits, and one for broadcast amplification. Each of these amplifiers has an undistorted power capacity of +32 db. above a zero level of 6 milliwatts. Means are provided for switching the output of these power amplifiers to the various circuits and for matching impedances.

Program circuits to guest rooms are distributed from a central distribution box through lead covered cables to outlet boxes in three riser shafts, the first extending the full height of the building, the second to the 21st floor, and a third to the 17th floor. Three 152-pair cables of No. 16 B&S gage wire are installed in these shafts, two in the first and one in the second, with a similar 102-pair cable in the third shaft. Distributing boxes are provided on the various intermediate floors wherein wires from the cables terminate in sealing chambers. From these boxes circuits are distributed throughout the floors with a maximum of four groups connected to any one riser pair and a maximum of twenty rooms connected to any one group.

For the private rooms special loudspeakers were developed which can be plugged directly into the program distribution outlets. Each speaker is provided with a six-channel selector switch and a volume control. The energy level to the speakers is held in the main control room to such a value that the maximum output from any speaker will not be sufficient to annoy guests in adjacent rooms.

One of the outstanding features of the entire installation is the flexibility of equipment and complete interchangeability of all major elements. All units such as radio receivers, main amplifiers, power amplifiers and distribution units terminate in jacks so that they can be "patched" into a variety of different positions in the circuits. In addition the system has been so designed and laid out that maintenance problems will be simplified as much as possible and that in the event of trouble the affected portion of the system can be segregated readily.

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

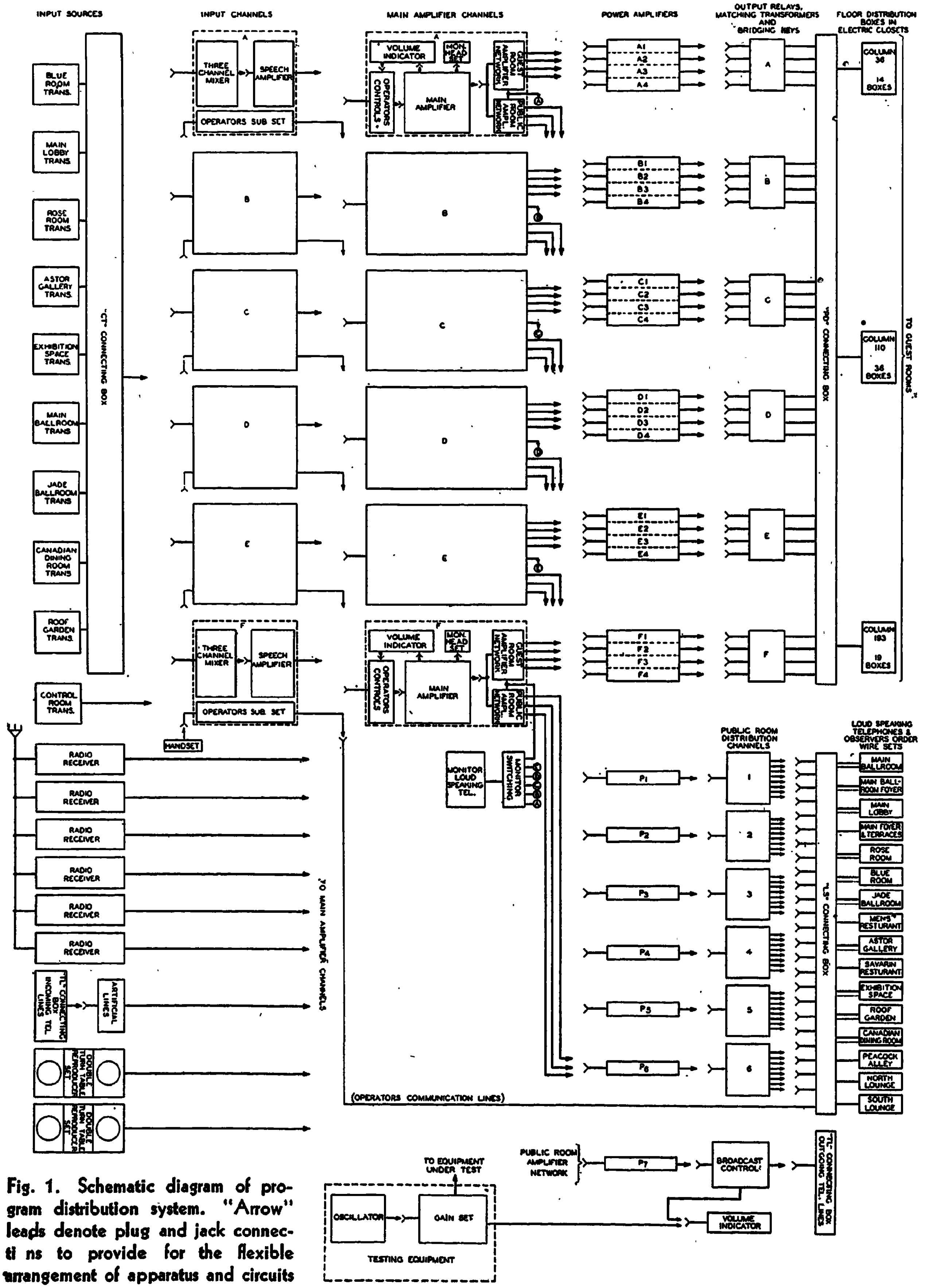


Fig. 1. Schematic diagram of program distribution system. "Arrow" leads denote plug and jack connections to provide for the flexible arrangement of apparatus and circuits

The entire program distribution system as well as the radio distribution system described in the following paragraph were designed by Bell Telephone Laboratories. The equipment was furnished by the Western Electric Company.

RADIO DISTRIBUTION SYSTEM FOR TOWER SUITES

In addition to the main antenna serving the six radio receivers of the program distribution system, two other antennas have been installed between the hotel's two towers. Specially shielded radio frequency distribution circuits connect each antenna to 69 tower apartments so that occupants of these suites may operate their own individual radio receivers therein. To operate such a large number of miscellaneous receivers from a single antenna without interference presented a difficult problem, the final solution of which consisted of supplying a separate radio frequency amplifier for each individual receiver. The circuits are so arranged that these coupling amplifiers are controlled by the same switch which controls the individual receivers themselves. Thus none of the amplifiers is turned on when not in use.

POWER SUPPLY

Since all electric power for the entire hotel is supplied from a d-c. system, special arrangements were necessary to furnish the program equipment with alternating current. For this purpose two 15-kw. motor-generator sets were installed in the power room on the seventh floor of the building, one being for regular use and one held as a spare. These are provided with automatic speed control to maintain proper frequency (60 cycles) and may be started, stopped, or otherwise controlled from either the power room or the control room on the floor below. These units are large enough so as to assure close speed and voltage regulation, and an unusually undistorted voltage wave under full system load.

OTHER EQUIPMENT

While the program and radio frequency distribution systems perhaps constitute the most novel features of the whole communication system, the telephone and teletypewriter systems are just as complete. They embody the latest developments in telephone engineering adapted to the needs of a modern hotel. The telephones may be divided into two main functional groups: one a manually operated system to serve the guests of the hotel, the other a dial system for use by the management.

About 3,200 telephones are provided for the use of guests in addition to the private telephones in the tower apartments served by individual lines from the central office. Of this total number about 2,600 are permanently connected extensions from a 28-position private branch exchange switchboard. The remaining 600 are portable instruments and may be conveniently plugged into auxiliary outlets with which some 600 of the rooms are equipped.

The telephone group for use by the management includes dial equipment sufficient to serve about 500 telephones in the executive offices, corridors, pantries, and other quarters occupied by the hotel personnel. These telephones may be interconnected with any of the manually operated instruments through the private branch exchange switchboard.

The teletypewriter installation comprises 66 machines, these also being divided into two main groups. The first group of these will be used primarily for transmitting to employees in every department concerned with their service, information pertaining to the arrival, change and departure of guests. The second group is provided with auxiliary order-taking equipment so that operators of the machines may take messages intended for guests directly from persons calling, and transmit them by wire to the guest's floor to be delivered when he returns, or to the bell captain so that the guest may be paged. With this system written messages may be transmitted from any of the sending machines in the telephone room to receiving machines accessible to the bell captain, porter, tower housekeeper, room clerk, valet, or to other receiving machines located on 22 floors, and in the tower office.

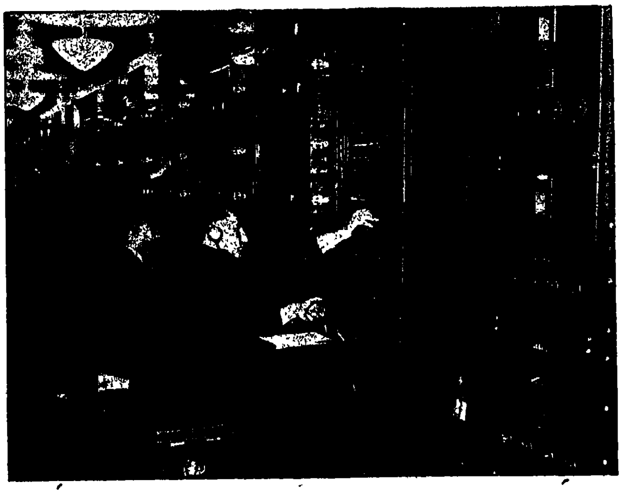


Fig. 2. General view of control room showing some of the 22 racks of amplifiers and other program equipment. Three of the six rack-mounted radi receivers may be seen at the right

Although not strictly concerned with communication equipment it may be mentioned that sound picture apparatus of the theatrical type has been installed permanently in the grand ballroom. Also one portable machine has been provided with which talking picture entertainment or lectures can be taken to any of the smaller public rooms.

Corona Versus Conductor Surface

Tests show that thin coatings of some materials reduce the corona losses from high voltage conductors, and that equal losses may be expected from weathered copper and aluminum wires of the same diameter. This investigation was suggested by previous tests (1930) made at the Ryan Laboratory, Stanford University; this earlier work indicated a temporary reduction in losses after the conductors had been cleaned.

By
W. D. WEIDLEIN
Black & Veatch
Kansas City, Mo.

IN THE INVESTIGATION described here, corona loss measurements were made on copper and aluminum wire (1) as received from the manufacturer (2) with different surface treatments and (3) after weathering. Test equipment was arranged as shown in Fig. 1 and was similar to the set-up used in the previous tests made in the spring of 1930 at the Ryan Laboratory, Stanford University. Test specimens consisted of 50-ft. lengths of No. 2 B&S gage solid conductors, supported 8 ft. 6 in. from the ground. The sag at the middle of the specimen was less than 2 in. in all cases with clearance in all other directions greater than 15 ft. In some of the tests, specimens were coated with different materials. The maximum increase in specimen diameter resulting from such treatment, however, was only 0.001 in., which would cause but very little variation of corona losses.

Insulator loss on the outer end is included in all results, but is negligible in amount; for comparative results this insulator loss does not enter in, since it was present in all tests. Insulators at the wattmeter end of the specimen were shielded so that their losses would not enter into the wattmeter reading. All tests were made within the laboratory and under as nearly similar conditions of temperature, humidity, and barometric pressure as possible.

In all tests after the specimen had been treated, the procedure followed was first to build up the specimen voltage to 100 kv. The loss at this voltage then was read, after which similar readings were taken for sucessively lower potentials at from 5-kv. to 2.5-kv. intervals, depending upon the rate of change in loss.

A comparison of losses from aluminum and copper conductors is shown in Fig. 2. The shape and shift of the curves between values of from 72.5 to 80 kv. should be noted. Joffe's theory that the resistance of a polarized layer decreases when the e.m.f. produced by polarization due to space charge exceeds 2,000 volts, ("The Physics of Crystals") is a very plausible explanation of this action. No doubt high loss from the copper conductor as received from the manufacturer is due to residue left from the "pickling" process or from drawing.

In Fig. 4 the first run (curve a-D) was made on a conductor coated with a thick film of linseed oil brushed on and dried. This wire then was cleaned and wiped once over its surface with a cloth soaked in linseed oil. A complete film was not formed, which accounts for the weathering and higher losses after drying. Curve 3-D gives the loss after wiping a second film onto the wire, and shows a decrease in losses at potentials near 75 kv. Apparently there may be some justification for the theory that with a complete thin film covering, ionizing velocities of electrons cannot be attained within the film because of an insufficient ionizing potential fall. Space charge then increases to a point where its leakage resistance starts to decrease, thus permitting a greater potential fall throughout the adjacent air and causing a sharper rise in corona loss.

In Fig. 6 curves are shown for copper and aluminum conductors, cleaned, and then suspended open to weather for about one month. These indicate equal losses for the two materials over the range tested.

Curve 3-F of Fig. 7 gives the results of a test made on a copper conductor coated with a smooth film of copper oxide formed by heating. While at 21 kv. corona was observed around this wire, no streamers formed over the range of voltage tested up to 150 kv. r.m.s. Other curves of Fig. 7 show the losses from a conductor after being heated in acetylene gas. Upon removal from the gas a granular deposit of carbon covered the conductor; the losses were as plotted in curve 1-N. After this carbon was rubbed off the losses were as plotted in curve 2-N. An interesting point in this connection was that carbon had been deposited to a depth of 1/16 in. into the conductor.

CONCLUSIONS

1. Thin films decrease corona loss.

Thin coatings of certain materials are effective in decreasing corona loss from high voltage conductors, whereas thicker films will increase such loss. Such a film may be the polished surface of a metal itself, or the formation of a film by materials which flow readily and solidify with a glaze or a crystalline surface.

2. Same losses for weathered copper and aluminum.

Corona losses from copper and aluminum conductors are practically equal after weathering, providing any detrimental effects remaining after drawing have been eliminated.

3. Favorable corona loss reduction indicated.

Favorable results in the reduction of corona loss are illustrated by the shape and shift of the curves in some cases. This conclusion is supported in several tests by deviation of the curves to the right from a straight line from high to low values of loss, and at voltages of from 72.5 to 80 kv. for the size of conductor used in these tests.

Based upon "Corona Energy Loss" (No. 31-139) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

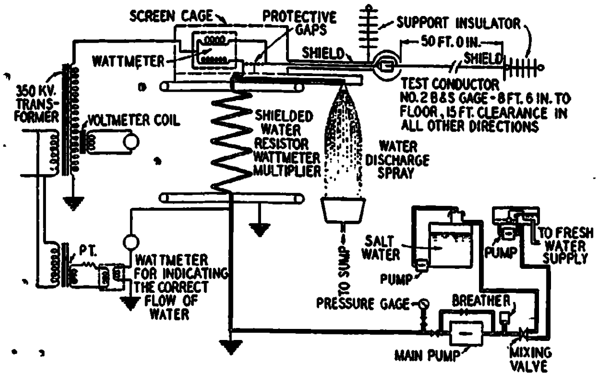


Fig. 1. (Left) Schematic diagram of test set-up

Fig. 2. (Right) Comparative tests on copper and aluminum specimens

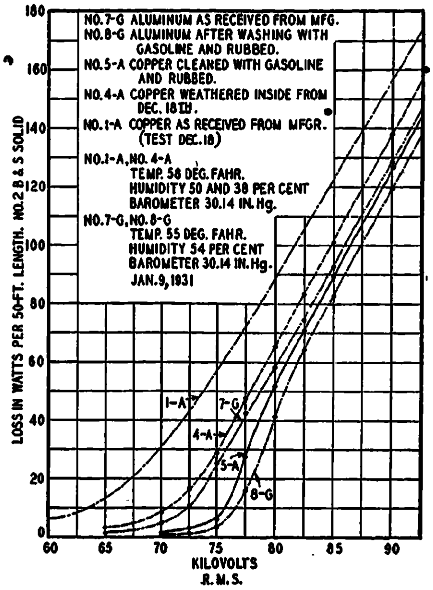
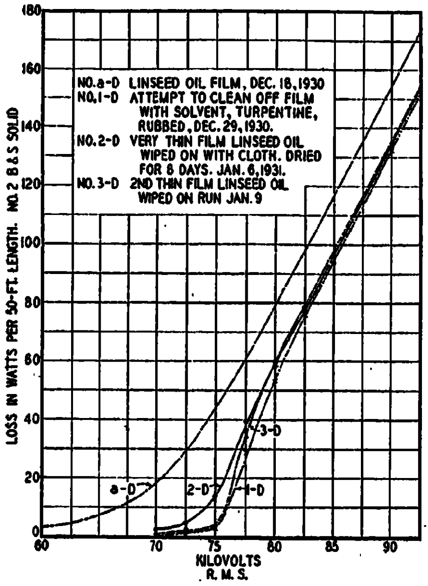
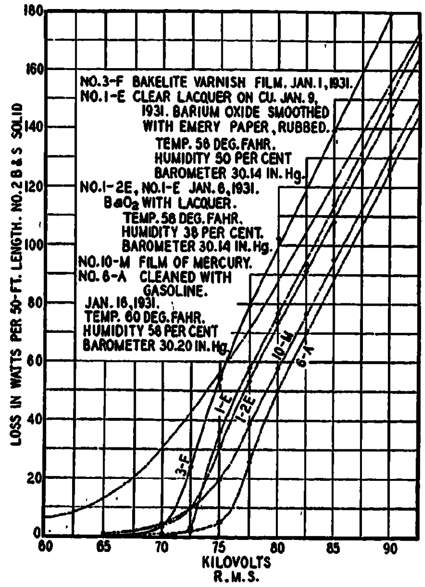


Fig. 3. (Below) Effect of linseed oil films of different thicknesses

Fig. 4. (Below) Effect of thin film coatings of different materials





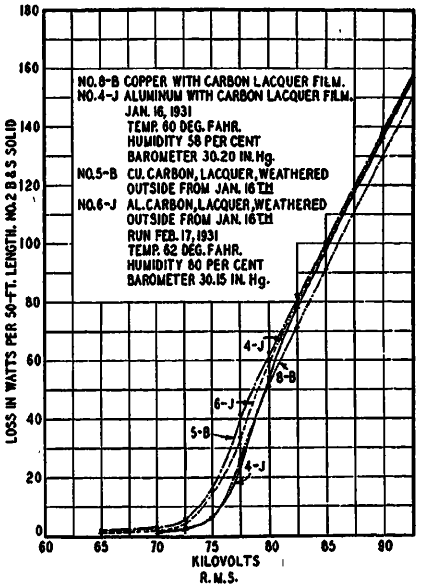


Fig. 5. (Above) Films of same material on both copper and aluminum

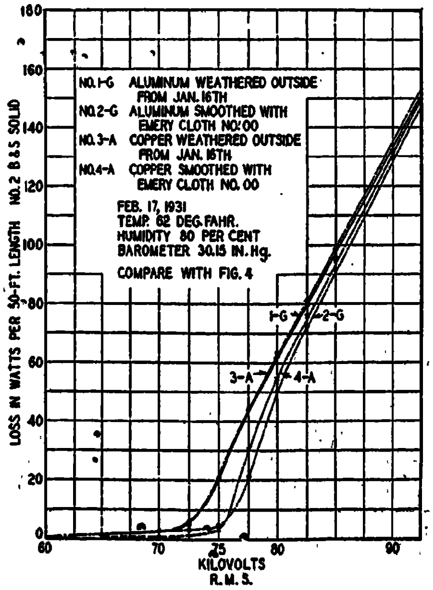
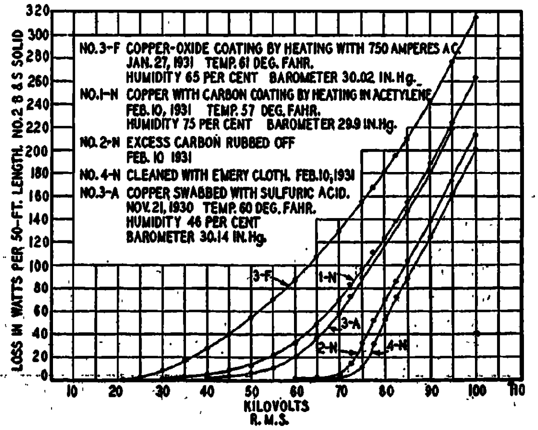


Fig. 6. (Left) Copper and aluminum conductors, first cleaned and then weathered, show equal losses

Fig. 7. (Right) Effects of oxide and carbon coatings on copper specimens



Abstracts

Of Papers Presented at the Kansas City District Meeting

INTERPRETIVE abstracts of all papers presented at the A.I.E.E. Kansas City District meeting (October 22-24, 1931) are presented herewith, excepting only those papers already published in this or preceding issues of ELECTRICAL ENGINEERING. Members vitally interested and wishing to obtain immediately pamphlet copies of any of these papers are requested to use the order form appearing on p. 920 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Electric Arc Welding in Building Constuction

By
P. N. Vinther[1]

ELECTRICAL ENGINEERING for October 1931, p. 785-7, contained an article based upon this paper. (A.I.E.E. Paper No. 31M8)

Effect of Wave Form on Operation of Induction Relays

By
P. H. Robinson[2]

INDUCTION type relays will of course operate at their intended current values and time settings only when the shape of the current wave applied during a fault is similar to that of the test wave. The shape of the current wave in the relay during fault is dependent upon the wave form of the fault currents and voltages, and the characteristics of current transformers and secondary circuits.

Although protective relays previously have been applied upon the basis that the wave shapes throughout were sinusoidal, and that the speed of operation of relays under test and under actual system faults for similar conditions were the same, the complexity of relay problems recently encountered requires a more careful consideration of wave form.

A detailed study indicates that the wave form of fault currents need be considered only in special cases such as the application of high-speed relays. However, even with ordinary-speed relays, current transformers may produce distortion of the secondary current during fault, and the use of such devices as auto-transformers, testing transformers and phantom loads in the relay test circuits often result in extreme distortion. In general, distortion of the current wave results in slower relay operation.

Circuits for secondary tests should be so proportioned as to give a current wave as near a sine form as practical. Air core inductance coils are very effective in correcting distorted wave forms arising from the characteristics of the test circuit. Primary test circuits having carefully selected equipment is of great value in obtaining over-all tests of current transformers, secondary connections and relays. (A.I.E.E. Paper No. 31M15)

A Telegraphic Pilot-Wire Relay System

By
C. H. Frier[3]

PUBLISHED in full in ELECTRICAL ENGINEERING for October 1931, p. 824-6. **Pamphlet copies not available.**

Calculating Load Division in Distribution Systems

By
C. T. Almquist[4]

A COMPARATIVELY simple and convenient method is available for solving the division of current in the various sections of an electrical network and obtaining the voltages at the different load points. The method consists essentially of the application of Kirchoff's laws to the solution of a network, the departure from the usual procedure being that instead of solving a number of simultaneous equations, the problem is handled in steps by the superposition of currents. The idea of a circulatory current is introduced when any change in the system is made by a closure between two points in the existing system.

While the method outlined is a step by step method, each step in the solution is of value in that it indicates the results obtaining for the different possible conditions of operation of the system. The application of the method is to the loop and network circuits encountered in power distribution. By its use relatively simple network circuits may be solved without the use of a calculating board. (A.I.E.E. Paper No. 31M9)

Overvoltage on Transmission Systems Caused by Dropping Load

By
E. J. Burnham[5]

THE INCREASE in voltage resulting from total or partial loss of load is especially undesirable on waterwheel driven generators because of their regulation characteristics and the fact that they are frequently connected to long lengths of high tension transmission line. The charging current of such lines results in a further increase in voltage. Although various types of relays have been used to trip the generator on the occurrence of excessive voltage or speed, a more desirable method of limiting the voltage is by the use of generator voltage regulator acting in the generator or exciter field circuit.

---

[1] Dallas Power & Light Co., Dallas, Texas.

[2] Houston Lighting & Power Co., Houston, Texas.

[3] Oklahoma Gas & Electric Co., Oklahoma City.

[4] University of Oklahoma, Norman, Oklahoma.

[5] General Electric Co., Schenectady, N. Y.

Tests have been made on a 47,000-kva. generator making use of a newly developed generator voltage regulator with a wheatstone bridge type of main exciter field rheostat, so adujsted that the exciter voltage may, if necessary, be reduced to a slightly negative value, thus quickly reducing the generator field current and limiting the generator armature voltage. This equipment ordinarily functions to maintain the alternating voltage normal, but at the same time is constantly ready to prevent the voltage from reaching dangerous values which would overstress the insulation of generators and connected apparatus at such time as loads might be dropped on the generating unit. The use of such equipment has made it possible to design lightning arresters and protective apparatus to give better protection.

An alternative method which is less expensive and which may be applied to older machines where it is not desirable to change the exciter to a quick response type, consists of automatically inserting a block of resistance in the alternator field circuit. This method, although not giving accurate regulation, has been found effective in keeping the voltage within desired limits when load is lost. **(A.I.E.E. Paper No. 31-140)**

Backfires in Mercury Arc Rectfiers

By
J. Slepian[6]
L. R. Ludwig[6]

A COMPREHENSIVE abstract of this paper was published in Electrical Engineering, October 1931, p. 793-6. **(A.I.E.E. Paper No. 31-132)**

Impulse Voltage Tests on a 4.8-Kv. Distribution Substation

By
H. W. Collins[7]
E. E. Piepho[7]
J. J. Torok[6]

DISTRIBUTION lines from ungrounded 4,800-volt substations of the Detroit Edison Company commonly have several hundred feet of three-phase underground cable between the overhead lines and the station, voltage regulators being connected between the bus and the station end of the cable. Although lightning arresters are connected at the substation bus and at the junctions of the overhead lines and entrance cables, a number of flashovers due to lightning voltage have occurred, consistently between the line terminal of the regulator and the station end of the entrance cable.

As the result of a series of impulse voltage tests, two forms of protection were found to be effective in preventing the surge voltage rising to values sufficient to break down the entrance cable or cause flashovers at the station end. Low voltage lightning arresters shunted across the regulator series windings operate in series with the bus arrester and limit the rise of voltage on the line side of the regulator to the sum of the breakdown voltages of these two sets of arresters. The second method, and the one which is more desirable because it insures a lower voltage at the substation end of the cable, is to connect lightning arresters at this point. They limit the voltage on the substation pothead and on the regulator; and, acting in combination with the arresters on the bus and at the outside end of the cable, limit the voltage in the cable to the drops across the arresters. **(A.I.E.E. Paper No. 31-133)**

Interconnection of the 25- and 60-Cycle System of the Union Electric Light & Power Co.

By
L. V. Nelson[8]
E. L. Hough[8]

FREQUENCY conversion was determined as the best means of supplying differences between the 25-cycle and 60-cycle loads and generating abilities of the Union Electric Light and Power Company system. The hydroelectric plant at Keokuk, Iowa, was developed as a 25-cycle run-of-river plant to supply the 25-cycle load in that vicinity and to transmit power to St. Louis, where the load is largely 60 cycles. Various possibilities in 25-cycle and 60-cycle steam and hydroelectric plants presented themselves but a frequency converter was decided upon as the most desirable.

After a careful study of the five types of machines available, it was decided to purchase two variable ratio synchronous induction converter sets, each capable of transmitting 20,000 kw. in either direction, with variation from normal frequency of ½ cycle in either direction on each system.

The machines are of the six-bearing horizontal type with provisions for movement of stators to permit easy maintenance or repair. A split coupling is provided between the two main machines and the starting motor and d-c. exciters are on the 60-cycle end to permit the operation of the latter as a synchronous condenser independent of the 25-cycle machine.

It has been found that the inherent ability of the machines to change load gradually with system speed changes has been of marked benefit in stabilizing the systems. The 60-cycle machines are equipped with high speed excitation systems to hold the voltage within narrow limits, and the corrective capacity in the induction units exerts a remarkable stabilizing influence on the 25-cycle voltage. **(A.I.E.E. Paper No. 31-137)**

Automatic Control for Variable Ratio Frequency Converters

By
E. K. Shively[8]
G. S. Whitlow[9]

AUTOMATIC switching equipment for the control of two 20,000-kw. frequency changer sets using the Scherbius method of load and power-factor control has been in successful operation at the Page Avenue station of the Union Electric Light and Power Company of St. Louis for almost a year.

The switching equipment is designed so that the starting, synchronizing, voltage control, loading limiting features, and protective devices are completely automatic. The performance of this equipment during all sorts of system conditions during the past year has demonstrated the feasibility of automatically controlling large frequency changer sets. The stabilizing effect of the 60-cycle high speed excitation system on the voltage during system short circuits and the accuracy and speed of the 25-cycle synchronizing operation are of special interest. Although manual synchronizing of the 25-cycle unit is difficult because of the complex character of the excitation system and the constantly changing value of slip frequency, this operation is performed automatically in a very short time and with no interchange of power between the two systems. (A.I.E.E. Paper No. 31-136)

---

[6] Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
[7] Detroit Edison Co., Detroit, Mich.
[8] Union Electric Light & Power Co., St. Louis, Mo.
[9] General Electric Co., St. Louis, Mo.

Forecasting Population for Engineering Purposes

By
J. N. Holsen[10]

ENGINEERS and persons responsible for the management of engineering projects have a common interest in problems of forecasting population growth and market demands. The soundness of engineering projects depends upon their capacity to fulfil a real demand. Unsoundness or even failure may result from planning and designing engineering projects without regard to industrial and population trends. Similarly city planning, housing and home building projects, educational and social programs of various kinds, ordinarily should be based upon the number of people to be served at some future date and their economic and social characteristics.

Population forecasts, when carefully and intelligently made, serve a valuable purpose in helping to direct the employment of labor and capital to places or projects where they are most needed. What will most probably occur is always the first consideration in population forecasting. Sound forecasts cannot be made to rest upon a local point of view; national factors are always involved, frequently international. In boom periods it is necessary to guard against the tendency to overestimate, while the reverse is true of dull periods. Because of the fundamental influence of economic and geographic factors in determining the population growth of cities or regions, the economic survey is invaluable in determining the probable future number of people in a particular city or region, and their social and economic characteristics. Meticulous precision is impossible in making long range population forecasts, but it is both possible and practicable to obtain a valuable working knowledge of conditions in the future. (A.I.E.E. Paper No. 31-138)

Advance Planning of Long Distance Telephone Facilities

By
C. C. McFarland[11]

THE RAPID increase in the size and complexity of the toll plant during recent years has emphasized the need for careful advance planning. This involves the development of an ultimate plan which indicates the most economical and desirable toll plant arrangement some 15 years in the future.

In developing an ultimate plan, estimates of future traffic and the corresponding circuit requirements are of great importance as are likewise the classification of the various towns and exchanges into tributaries, toll centers and switching points. Several possible arrangements of plant which will provide for the estimated circuit requirements and meet the service standards at the ultimate period are studied. Judgment must be exercised in deciding on the most desirable ultimate plan, due weight being given to such factors as cost, flexibility, and protection service.

Advance planning also is necessary in connection with individual projects involving additions and extensions to the toll plant particularly for the projects involving commitments for a number of years in the future. Several feasible plans of providing the plant are studied, the ultimate being used as a guide in setting up intermediate plans. Cost studies over a period of 5 to 15 years are made to determine the most economical scheme. (A.I.E.E. P per No. 31M14)

Tape-Armored Telephone Toll Cable

By
C. W. Nystrom[10]

BURIED tape-armored cables possess several advantages over cables carried on pole lines or in underground conduit:

1. Easements for buried tape-armored cable on private rights-of-way may sometimes be obtained more cheaply than for pole lines, as the use of the land for ordinary agricultural activities is not disturbed.
2. Induced currents from paralleling power lines are appreciably less than in unarmored aerial or underground cables, due to the shielding effect of the steel tapes.
3. Cable may be laid to follow the contour of rough country and have sharp bends to avoid obstructions, while conduit must have a fairly even grade and long radius curves to permit cable being pulled through it.
4. Manholes are required at spacings of from 500 to 700 ft. if conduit is provided, while with tape-armored cables, manholes may be omitted except at loading points which normally occur at 6,000-ft. intervals.

On the other hand, as tape-armored cables are buried directly in the earth, the location and repair of troubles are generally more difficult and more expensive than for aerial cables. However, improvements in methods for maintaining buried cables should reduce such costs, and in any event the amount of trouble per cable mile may be expected to be much less than on aerial cables, because of their security from fire, storm, and bullets.

Tractors, plows, trench backfillers, and other cable laying equipment have been developed. As a result tape-armored cable can be laid at a cost only slightly greater than that of aerial cable on pole lines, and developments now under consideration promise a rather substantial reduction in the cost of buried cable. (A.I.E.E. Paper No. 31-134)

The Time Factor in Telephone Transmission

By
O. B. Blackwell[12]

FOR ORDINARY distances of telephone communication, the speed of transmission can be considered as instantaneous. The increasing use of long distances for commercial telephony, however, has introduced time problems in telephone transmission which are of considerable technical interest and difficulty. Although a number of papers have been presented on this subject, none seems to have given a general over-all picture.

In actual telephone circuits the speed of transmission is reduced from the speed of light by the impedance of the circuit, and varies considerably in different circuits. Five different types of problems in telephone communication are introduced. First, conversation may be slowed down by the time interval between the formation of a sound by the speaker and its reception by the listener. In two-way conversation this may become important as it causes a delay in reply. Second, differences in the speed of transmission of the frequencies which make up speech may produce peculiar distortions which cause considerable interference. Third, echo effects may arise from the reflection of energy at points of irregularity, particularly at the end of the circuit. These echoes have the greatest effect on the talker who may have an uneasy feeling that the distant party wishes to break in on the conversation. Fourth, the voice-operated devices which are sometimes connected in the circuit, and which overcome echoes by rendering inoperative transmission in the opposite direction, may result in a delay in transmission and introduce other serious difficulties. The fifth factor is that of fading, which although not included in this discussion may result when there is more than a single path between the sending and receiving ends of a circuit. **(A.I.E.E. Paper No. 31-135)**

---

[10] Southwestern Bell Telephone Co., St. Louis, Mo.
[11] Southwestern Bell Telephone Co., Kansas City, Mo.
[12] American Tel. & Tel. Co., New York, N. Y.

Lightning Disturbances on Transmission Lines

By
D. C. Jackson, Jr.[13]
R. W. Warner[13]

MOST OF THE more important studies of lightning disturbances on transmission lines have been confined to steel tower lines of 110 kv. and above. A field investigation of the effect of lightning on 33-kv. and 66-kv. transmission lines on wood poles is now being carried on, the preliminary investigations having been completed.

Data have been compiled showing the direct lightning hits and flashovers per pole in the Mississippi and Missouri River valleys. These indicate for example that guyed poles are more subject to disturbances than unguyed poles, and that corner poles also are more frequently affected. It was found that in the case of 66-kv. lines practically two-thirds of the guyed poles were hit or flashed over, whereas only about one-half of the guyed poles on the 33-kv. lines experienced lightning troubles. The proportion of unguyed poles affected was practically the same for both voltages.

The data indicate that there is little difference between the amount of lightning trouble experienced by poles in rolling country and by those in flat river bottoms. It is stated that whether pole stands on the crest of a hill, on a slope, in a valley, or on open low land has little effect on the number of lightning disturbances. It is hoped that the continuance of this investigation will produce definite explanations of the causes of the phenomena observed. **Pamphlet copies not available.**

Corona Energy Loss

By
W. D. Weidlein[14]

PRACTICALLY the full text of this paper is published in this issue of ELECTRICAL ENGINEERING, pp. 898-900. **(A.I.E.E. Paper No. 31-139)**

Application of Primary Distribution Fuses

By
F. E. Sanford[15]

THE FUNCTION of the primary fuse is to clear short circuits, and to minimize disturbances to the system at times of fault. Continuity of service requires that short-time overloads should not cause primary fuses to blow, whereas fire hazard requires that fuses for secondary windings operate on an overload basis. The proper application of primary fuses is dependent upon the determination of the available short-circuit current as well as the value of load current. Another factor which must be given consideration is coordination of fuse and relay time-current characteristics to insure isolation of the fault at the fuse point rather than by the main feeder switch. Minimum time of operation should be sought in the selection of fuses, both to provide maximum flexibility in relay settings and to give minimum system disturbance. The time required for a fuse to blow in the short-circuit current range is more important than at the one or five minute points.

To be consistent with the rating of other electrical equipment, fuse ratings should be based upon their continuous carrying capacity. Ratings on some other basis are likely to cause confusion, and to make an accurate comparison between different types of fuses difficult. Consistent ratings also would facilitate interchange of fuses of different types. **(A.I.E.E. Paper No. 31M10)**

The Expulsion Fuse

By J. Slepian[6]
C. L. Denault[6]

THE EXPULSION fuse is an extremely simple device used quite extensively for interrupting a-c. circuits of moderate voltage and power. In spite of its apparent simplicity and widespread use, the principles upon which it functions are not at all generally understood. Comparisons of interrupting capacities of a soapstone fuse tube and a fiber fuse tube, support the view that the expulsion fuse depends upon the gas blast produced by rapid decomposition of fuse tube material under the heat of the arc. The effectiveness of the gas blast is stated to be due to the high degree of turbulence it introduces into the confined arc space.

The voltage interrupting capacities *versus* ampere capacities for a fiber tube and for a boric acid lined tube have been obtained experimentally, and it is found that the curves for boric acid lie much higher than for fiber. The characteristics were found to depend very materially upon the number of half cycles of arcing. Also it has been found that the circuit voltage which can be interrupted rises rapidly as the size of tube is decreased.

An interesting development of the expulsion fuse is the use of flame suppressors for deionizing the issuing flame. It has been shown that by introducing means for condensing the water vapor, the boric acid lined tube may be completely closed without the development of excessive pressure. In fuse design, consideration must be given to insure that the gas generating materials which aid in arc extinction will withstand the full circuit voltage with the passage of only small current, even when heated by the arc. **(A.I.E.E. Paper No. 31-141)**

Fuse Cut-Outs—Their Design and Application for A-C. Distribution Circuits

By
E. G. Newton[16]

MANY NEW developments to meet modern requirements have been applied to the renewable expulsion-fuse and oil-fuse cut-outs for a-c. distribution systems of 15,000 volts and below. While there are several different types of fuse cut-outs, the universal design problem is the interruption of an arc formed when the current carrying element melts. Both expulsion-fuse and oil-fuse cut-outs depend for this interruption upon the gas pressure generated by the current in the arc.

Three factors, circuit voltage, load current, and fault current govern the proper selection of fuse cut-outs and fuse links to meet the different service requirements. These factors are shown to have a relationship necessitating equal consideration in order to secure safe and reliable operation. Coordination also must be secured with other apparatus on transmission and distribution systems. Investigations now being made on the effect of power factor on arc interruption may have an important bearing on the future design of fuse cut-outs. **(A.I.E.E. Paper No. 31M11)**

---

13. University of Kansas, Lawrence, Kansas.
14. Black & Veatch, Kansas City, Mo.
15. Union Gas & Electric Co., Cincinnati, Ohio.
16. General Electric Co., Pittsfield, Mass.

News
Of Institute and Related Activities

Thomas Alva Edison—
February 11, 1847-October 18, 1931

BRINGING to a close one of the most colorful careers in history, Thomas Alva Edison, indefatigable promoter of the incandescent electric lamp, quietly breathed his last at 3:24 a. m. October 18, 1931, almost exactly 52 years after his invention of that lamp. He died at "Glenmont" his West Orange (N. J.) home in which he has lived since 1886. Apparently convinced for some weeks that his many sided life work was at an end, he is reported as having expressed a feeling of "inadequacy" for the continuation of the tasks to which he has devoted his best efforts during his allotted span of years.

Thomas A. Edison's characteristic, clear cut signature occupies a prominent place upon the original call issued in the spring of 1884 for the organization meeting of the American Institute of Electrical Engineers. This historic document, which occupies a conspicuous place in the members' room at Institute headquarters in New York, stated that "it seems probable that the persons who are interested in electrical, scientific, educational, manufacturing, telegraphic, telephonic, and like concerns, as well as the users of electrical appliances generally, will find it to their advantage, personally and collectively, to establish, support, work for, and generally aid our proposed Society."

Edison not only was one of the organizers of the Institute, but at its first election of officers, May 13, 1884, he was elected a vice-president. Thus, while electricity surely was in its infancy, Edison was actively interested in creating an organization the objects of which were to be as they still are as stated in its Constitution "the advancement of the theory and the practise of electrical engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members."

Edison Medal Established

In recognition of the inspiration to workers in the fields of engineering and science as provided by Edison's spirit and character in his life work, the Edison Medal was established in 1904 by an organization of associates and friends of Edison, "for the purpose of appropriately recounting and celebrating the achievements of a quarter of a century in the art of electric lighting with which the name of Thomas Alva Edison is imperishably identified. The A.I.E.E., in response to an invitation, undertook the responsibility of making the awards of this gold medal which its sponsors designated should "during the centuries to come serve as an honorable incentive to scientists, engineers, and artisans, to maintain by their works the high standard of accomplishment set by the illustrious man whose name and features shall live while human intelligence continues to inhabit the world." The first award of this medal was made to Dr. Elihu Thomson in 1909; subsequently to: Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John W. Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, Frank Conrad.

In June 1928 the A.I.E.E. was privileged to give further recognition to Edison's services and achievements. The Constitution provides that Honorary Members may be chosen, upon the unanimous vote of every member of the board of directors, from among those who have rendered acknowledged eminent service to electrical engineering. Prior to June 1928 the very few distinguished persons thus elected all were from foreign countries, but at that time Edison's name headed the list of five outstanding American engineers unanimously endorsed by the directors.

The Genius of Edison

In his biography "Edison As I Know Him," Mr. Ford described Edison as "a genius but not in the sense that his inventions and discoveries have been revealed to him in sudden flashes. If he

Two "wizards" at work—Edison and Steinmetz examining porcelain insulators fractured by artificial lightning were that, he would not have his present tremendous importance, for the lessons of his life would not have universal application. As it is, his methods can be used by any one; and the fact that they are being used by so many is one of the reasons for our great industrial progress. The man stands as a demonstration of what concentration and intelligence can accomplish."

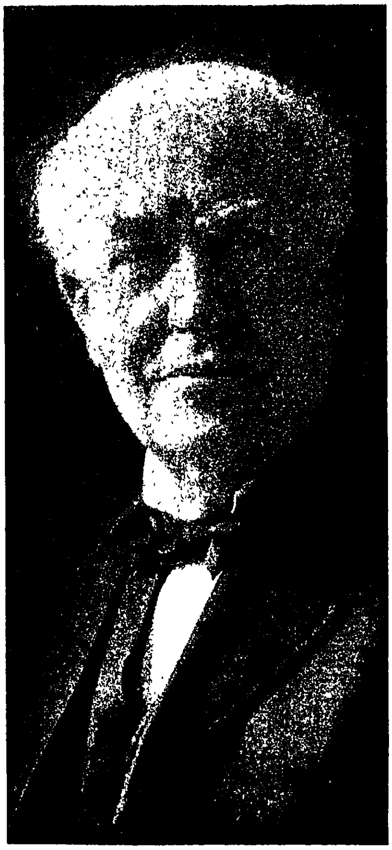
One of his earlier interests and certainly the one most consistently and earnestly pursued by Edison through and in spite of seemingly insurmountable difficulties, was the development and improvement of the incandescent electric lamp and a parallel system of distribution which would make electric light as readily accessible to the individual consumer as the older established utility systems which provided water and gas service.

Other experimenters had been busy on the problems of both the arc light and the incandescent light, the former of which already had reached a successful commercial stage. Self-exciting generators for both continuous and alternating current had been developed, and as early as 1859 Prof. Moses G. Farmer had conducted successful experiments with incandescent lights comprising a metal filament enclosed in a glass globe from which air had been partially exhausted. It had been predicted by Professor Farmer that the success of the incandescent lamp would hinge upon successful accomplishment of the necessary vacuum. Edison, after contemplating the limitations of the arc light, disregarded contrary current opinion and in the face of ridicule and violent criticism turned his tireless, bold, and imaginative effort toward the development of a commercially successful incandescent electric lamp. Thus it was that on October 21, 1879, Edison achieved his first successful incandescent carbon lamp, the tiny foundation upon which has been built a five billion dollar industry.

THE THREE WIRE SYSTEM

With the fundamental problem of the incandescent lamp settled, came the demand for improved types of dynamo-electric machines and the development and improvement of commercial distribution systems for electric energy. To meet these demands Edison's tireless work of 1879-80 laid the foundation and unerringly pointed the path which the successful commercial development of electric lighting must follow. It is of interest to note here in passing that Edison was unalterably opposed to the evolution and development of the alternating current system.

The Edison three wire system of distribution, really a multiple-series grouping of lamps supplied by dynamos connected in series with a grounded balance wire between the dynamo connection points and the lamp groups, was as fundamental to the advance of electric lighting as the development of the lamp. As with the lamp itself, the three wire system was invented independently in England, but again it was Edison's driving energy and deep insight that underlay commercial success. The famous Pearl Street station in New York City, the first central electric generating station in the western hemisphere, followed almost immediately upon the completion of a similar station at Holborn Viaduct in London where two 1,000-light Edison generators were placed in service in 1882.



Thomas Alva Edison—

"It is given to few men of any age, nation or calling to become the benefactor of all humanity. That distinction came abundantly to Thomas Alva Edison, whose death in his eighty-fifth year has ended a life of courage and outstanding achievement. His lifelong search for truth, fructifying in more than a thousand inventions, made him the greatest inventor our nation has produced, and revolutionized civilization itself. He multiplied light and dissolved darkness; he added to the whole wealth of nations. He was great not only in his scientific creative instinct and insight, but did more than any other American to place invention on an organized basis of the utilization of raw materials of pure science and discovery. He was a rare genius. He has been a precious asset to the whole world.

"Every American owes a personal debt to him. It is not only debt for great benefactions which he has brought to every American, but also debt for the honor he brought to our country. By his own genius and effort he rose from a newsboy and telegrapher to the position of leadership amongst men. His life has been a constant stimulant to confidence that our institutions hold open the door of opportunity to those who would enter. He possessed a modesty, kindliness, a stanchness of character rare among men.

"His death leaves thousands bereft of a friend, the nation bereft of one of its notable citizens and the world bereft of one of its greatest benefactors. I mourn his passing as a personal friend over a quarter of a century."—

HERBERT HOOVER

EARLY INVENTIONS

Legitimately hailed as the father of commercially successful electric lighting as it now is known throughout the world, Edison also was the developer and inventor of other ideas, methods, and apparatus entirely too numerous to mention. The record of his inventions at the United States Patent Office shows that since 1868 more than 1,200 patents have been granted to Edison covering an astoundingly wide range of subjects. Prior to his successful development of the incandescent electric lamp in 1879, Edison had invented the phonograph (1877); completed basic inventions in automatic telegraph systems, multiplex telegraph apparatus, and a carbon telephone transmitter which was used by Doctor Bell in the commercial application of his own telephone instrument (1871-77); contributed to the development of the successful working model of a typewriter (1871); contributed inventions fundamental to the ultimate successful development of the stock ticker (1870). His first recorded invention (1868) was his electrochemical vote recorder which he patented with the idea of having it installed in the houses of Congress. As a commercial venture, however, this first recorded patent was a complete failure, the result of which was to cause Edison to devote his subsequent efforts to the development of apparatus for which he could see a reasonably sure market as a reward for the achievement.

THE PHONOGRAPH

The invention of the basic idea of the phonograph and the development of related materials and apparatus is credited without even the shadow of a competitive claim to the ever-questing inventive brain of Mr. Edison. Imbued with the idea that he could make sound waves record themselves mechanically to be reproduced subsequently at pleasure, Edison is credited with having developed his phonograph within one week after having first set to work at it. This invention is regarded as illustrating Edison's mastery of many fields. It is evident that his previous work in the development of a commercially successful telephone transmitter provided him with a background of experience and experiments which enabled him to make such startling developments with his phonograph idea.

THE "EDISON EFFECT"

In 1883 the phenomena later described as the "Edison Effect" was noted by Edison and discussed at some length by contemporary electrical engineers. In fact, at the first meeting of the Institute held at Philadelphia, Pa., in October 1884, a paper was presented by Dr. Edward J. Houston, "Notes on Phenomena in Incandescent Lamps," and this paper may be found as the first paper in Vol. 1 of the TRANSACTIONS of the Institute. The discovery of this "Edison Effect" was the fundamental root system upon which was based and from which grew the great radio industry of today, including the thermionic tubes that have been developed for purely industrial purposes. This important fundamental discovery, stumbled upon by the noted inventor, lay dormant for more than 30 years while its discoverer devoted his energy to other and more obvious projects. As was typical with the more or less incidental discoveries made by Edison, he no sooner had evolved the principle than he discarded it when it failed to bear fruit.

Edison's first glimpse of this all-important principle underlying the thermionic tube of today was described in an article in *The Atlantic Monthly* for December 1930:

"While working on his incandescent lamp in 1883 Mr. Edison noticed that when he heated the filament to a certain temperature a blue glow appeared between the legs. Was this electricity flowing through rarefied air? If so, it seemed strange that the current should take this more resistant path in preference to the easier channel provided by the loop filament itself. To satisfy his curiosity the inventor inserted a second element into the bulb—a wire. He connected the wire to the positive terminal of the lamp and found that a weak current did flow from the hot filament, but, curiously, when the connection was changed to the negative terminal, no current flowed.

"Edison noted the experiment in his notebook and turned from this fascinating side issue back to his main job of developing the incandescent lamp. . . .

"It was not until 1905 that this flow of power in a vacuum was harnessed to do useful work."

Thomas A. Edison as Seen by Some Institute Leaders

LEWIS B. STILLWELL—Edison's greatest contribution to mankind was the incandescent lamp and the central station for supplying electricity through feeders and mains to adjacent territory. Next to this achievement, his greatest contribution, perhaps, has been the stimulus of his example. His simplicity of life, his untiring industry, and his infinite patience in overcoming difficulties have been an inspiration to countless workers.

GANO DUNN—If for no other reason, Edison will be immortal as the first man to record and reproduce human speech. His contributions to electrical generation, distribution, and illumination, without including the invention of the phonograph, place his name among the great ones of the earth. In his death I lose an inspiration and a kind personal friend from boyhood, whose youth and vitality of personality blazed to the last as a light to the world.

HARRIS J. RYAN—Mr. Edison was much more than the inventor of the incandescent lamp, the phonograph, and the motion picture. He will rank forever with the greatest practical explorers of the feasibles and permissibles that determine human welfare and happiness on this earth. He did a lion's share of the work that will forever distinguish the transition from the 19th to the 20th century. He was a philosopher who, by his example, taught millions the glory of unremitting toil.

A. E. KENNELLY—We of the electrical engineering fraternity deeply regret the loss of our great American inventor, Thomas A. Edison. As his principal electrical assistant from 1887 to 1894 it was my privilege to work with him daily. His great energy and enthusiasm made those years very happy and memorable to me. As a chief, he was always inspiring, encouraging, and sympathetic, and all of us at the laboratory revered and loved him. We forgot obstacles and even the passage of time, in our work under the direction of his grand personality.

M. I. PUPIN—Edison's greatest contribution to the comforts of mankind undoubtedly is the incandescent electric lighting system. Edison always loved to reminisce about his wonderful experiences in the course of developing the incandescent filament, and no biography will be complete without these reminiscences. This development work, crossed at every step by almost insurmountable difficulties, illustrates better than anything else Edison's genius. He was a great inventor, but he was also a great personality, the unique combination of the two will never be forgotten.

C. E. SKINNER—The name of Thomas A. Edison and the development of the electrical industry are and will be inseparable. His contributions to the electrical art, as well as to many other subjects, have been continuous for more than fifty years. His research has been characterized by tireless energy and a mind which led him to try methods and materials for the attaining of his objectives which perhaps would never be thought of by the average research worker. In his passing the electrical industry loses its greatest pioneer and the world an unique and outstanding figure.

MOTION PICTURE DEVELOPMENT

Work done by Edison in 1889-90 and 1891, resulted in his achieving basic inventions in the field of motion picture recording and projecting. This work was followed by additional developments during the ensuing 35 years or more which contributed toward the development of successful motion picture apparatus. It is interesting to note in this connection that although Edison made inventive contributions of the greatest importance in the field of the phonograph and the photographic film for the recording and reproduction of sound waves, and also in the field of motion picture recording and projecting, it is reported authentically that Edison was convinced even up to his last active days that the combination of sight and sound in the form of the modern talking motion picture would prove to be but a passing public fancy and, therefore, not attractive enough to him to cause him to devote serious energy to it.

EDISON IN CHEMISTRY

Edison had a strong liking for experimental work in the field of chemistry, an interest which periodically had burst into flame during his many years of development efforts, but which always had been pushed into the background to keep the way clear for his other major activities. However, the participation of the United States in the World War and Edison's immediate devotion of effort to government service gave him the opportunity to "putter" with chemicals, something which for several years he had been hoping for privately. Faced with a direct need for carbolic acid, aniline dyes, and other chemicals in this country, normal supplies of which had been interrupted by war conditions, Edison took great pleasure in the fact that "within sixty days after we decided to make carbolic acid we had a plant built and were making it."

As head of the United States Navy Consulting Board (1915) and life head of the United States Naval Recruiting Board (1917) Edison devoted his seemingly tireless energy to the development of vitally important new war materials and equipment. After the war Edison devoted much attention to the project of developing a domestic rubber supply and experimented with synthetic products. As usual, however, this was just one of his many and widely varied activities.

Space limitations prohibit the reproduction here of anything like a complete life story of Mr. Edison's many sided activities. Those interested in the details of the life of this inspired world character are referred to the biographies "Edison As I Know Him" by Henry Ford, "Edison, the Man and His Work," by Geo. F. Bryan, and the biography prepared by William H. Meadowcroft, historian for the Edison Pioneers, and lifelong associate of Mr. Edison.

Turning from Edison the inventor to Edison the man, one finds a simple, direct stable philosophy of living given such a dynamic force by the example of his devotion to his work that its stimulating and inspiring effect will outlive him by generations. Students in the fields of applied science have had in him an ideal by which to guide their ambitions; by his infectious enthusiasm and vitality of personality men of science and industry have been encouraged to redoubled efforts in the face of devastating adversities. By his example he demonstrated the glory of unremitting toil directed toward knowing things and doing things that are of service to humanity. Thus, recognition is due him by Humanity as well as by Industry. The fruits of Edison's vigor, indomitable courage, and simple, effective philosophy of hard work beyond doubt were made available to the world for an unusually extended period through the untiring ministrations of his wife, Mina Miller Edison. Thus also is a debt of gratitude owed to her.

November 15 Last Date For Suggesting Nominations

Actions specified in the Institute's constitution and by-laws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the Spring of 1932 will be held between November 15 and December 15. All suggestions for the consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, not later than November 15.

Secret Telegraph Messages.—A new and very successful means for telegraphic and wireless transmission in secret was described recently before the Academy of Sciences by General Gustave Ferrie of the French Institute. The new method makes use of devices in a French inventor's system of sending orthographic texts by means of cylinders moving at variable speeds and synchronized according to a prearranged plan between the sending and receiving stations. Each message bears the reproduction of the signature of the sender. It can be concealed further from any outside station by means of a simultaneous and more powerful text which has no connection with the secret message. General Ferrie stated that this system was expected to prove valuable for military and diplomatic communications.—*Telegraph and Telephone Age.*

In Memory of Thomas Alva Edison

The physical life of Thomas Alva Edison, world benefactor, ended on Sunday, October 18, 1931. The spiritual benefits of his contributions to humanity continue to live.

His genius, vision, patience, persistence, industry, and widely diversified talent, which brought to fruition many of his conceptions, have contributed greatly to the comfort, convenience, and happiness of mankind; his achievements constitute a great incentive and inspiration to those who follow.

In particular, his invention of the incandescent electric lamp and his conception, more than 50 years ago, of the combination of a central generating station with a suitable distributing system for electric energy firmly establish him as the founder of the electric lighting industry of the world.

He was the outstanding world leader in the group of inventors, scientists and engineers, whose achievements in technology have produced great social and economic benefits including the employment, in useful occupations throughout the civilized world, of tens of thousands of men and women.

He was respected and admired by his associates who cherish their memory of his ability, simplicity, and other personal characteristics.

Mr. Edison was, in 1884, one of the signers of the call for the organization of the American Institute of Electrical Engineers, and he was elected vice-president at the first election of officers; later he was elected an Honorary Member. His achievements caused a group of his associates and friends to establish the Edison Medal, which now is awarded annually by this Institute.

The board of directors of the A.I.E.E. hereby records in its minutes this appreciation of the great debt which the world, and electrical engineers in particular, owe to his memory, and directs that a copy of this minute be sent to his family.—From the minutes of the regular meeting of the board of directors, held at Kansas City, Mo., October 23, 1931.

Electric Furnaces Improved for Iron and Steel Plants

During the past two decades electric furnaces for melting and refining in the iron and steel industry have shown noteworthy progress. In a paper presented by W. E. Moore, metallurgical engineer of the Pittsburgh (Pa.) Electric Furnace Corporation, before the sixtieth general meeting of the Electrochemical Society held September 2-5, 1931, at Salt Lake City, Utah, it was stated that the electric arc type of furnace has increased sixty-five times in number, five times in maximum size per heat and ten times in maximum daily capacity. Power consumption was said to have been decreased from an approximate average of 700 to about 500 kw-hr. per unit ton output with a corresponding decrease in carbon electrode consumption from an approximate average of 35 to about 11 or 12 lb. per unit ton output. It is stated that by reason of these improvements, as well as by reason of the more rapid type of operation and lower maintenance, refractory, and slag costs, the total conversion cost has been reduced accordingly.

In comparing production figures it is stated that in 1910 ten electric steel furnaces were in operation in the United States producing 52,141 gross tons of electric steel during that year. In 1930 approximately 650 electric furnaces were in operation on iron and steel properties in the United States, giving an average annual output of more than 1,000,000 tons gross, of which approximately one-third was ingot and two-thirds steel and iron castings. It was stated further that approximately one-third of all steel for castings now is melted electrically.

Noble Prize Awarded by A.S.C.E.

Announcement just has been made of the award of the 1931 Alfred Noble Prize to Prof. C. T. Eddy, of the Michigan College of Mining and Technology, Houghton, Mich. This is the first award of this prize, which is accompanied by $500 in cash, and which should be of particular interest to all the younger members of the engineering profession.

The older members of that calling well remember Alfred Noble who, during a professional career of more than 50 years ending in 1914, participated in many public works for which the citizens of the United States still remain his debtors, although his characteristic modesty prevented his name being known in connection with them. His experience was of value in connection with the location and construction of the Panama Canal. He was one of the engineers who built the Pennsylvania (R. R.) Terminal in New York City. The project of bringing water from the Catskill mountains to the City of New York was guided in part by his knowledge and advice. In addition to his technical achievements, Mr. Noble took a great interest in the welfare of his colleagues, especially in the younger men who were just starting out in the engineering profession.

Very soon after his death, the American Society of Civil Engineers, of which he had been president in 1903, appointed a committee to collect funds for a memorial to perpetuate his memory. This finally has taken shape in a fund the income of which is to be used for an annual award of $500 to a younger engineer, who might thereby be encouraged in his chosen work and be led to emulate Alfred Noble, though he had never had the privilege of knowing him.

The prize is awarded upon the recommendation of a committee consisting of representatives from the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers. Award is made for a technical paper of particular merit written by a member of one of these societies, and accepted for publication before the author has reached the age of 30 years. Professor Eddy's paper, on "Arsenic Elimination in the Reverberatory Refining of Native Copper," to be published in the *Transactions* of the American Institute of Mining and Metallurgical Engineers, of which he is a member, was adjudged worthy of the first award. The presentation will take place at a future meeting of the A.I.M.E.; and the prize will be given to Professor Eddy by a representative of the A.S.C.E., trustee of the fund.

New York Power Group to Discuss Protection

The A.I.E.E. New York Section Power Group will hold a meeting devoted to power system protection on the evening of November 24, in Room 1, fifth floor, Engineering Societies Building, 33 West 39th Street, New York, N. Y. Addresses will be delivered by H. D. Braley, assistant engineer, New York Edison Company, and by H. P. Sleeper, engineer, Public Service Electric and Gas Company.

Mr. Braley will emphasize the necessity of planning protection in close conjunction with system design, both present and future; Mr. Sleeper will review pertinent operating experiences of his company with various types of system protection. Conforming to the established practise of the New York Section Groups, this meeting will be called promptly at 7:30 p. m. and will adjourn at 9:30 p. m. Discussion is open to all.

Administrative Engineering.—A new course in engineering leading to the degree of Bachelor of Science in administrative engineering has been included in the curriculum of Cornell University, Ithaca, N. Y., coincident with the academic year 1931-32. It is stated that this course has been instituted in answer to demands from industry for engineers having the training necessary to qualify for administrative responsibilities in engineering and industrial enterprises. The new course requires four years for completion and includes ten subjects of a non-engineering nature.

Leading Educator Dies

S. W. STRATTON

Dr. Samuel Wesley Stratton (A'04-F'24) chairman of the Massachusetts Institute of Technology Corporation and former president of M.I.T., died suddenly at his home October 18, 1931. Doctor Stratton was born July 18, 1862, at Litchfield, Ill., and was graduated from the University of Illinois in 1884 with the degree of bachelor of science in mechanical engineering. Later he received honorary degrees from the University of Illinois, Rensselaer Polytechnic Institute, University of Pittsburgh, Cambridge University (England), Yale University, and Harvard University. During the period of 1885 to 1892 he was instructor in mathematics, assistant professor, and later professor of physics and electrical engineering at the University of Illinois, organizing the department of electrical engineering at that institution. The following nine years he was successively assistant professor, associate professor and professor of physics at the University of Chicago, in 1901 becoming director of the National Bureau of Standards at Washington, D. C. Continuously from that time until 1922 he was director of this bureau, being responsible for its organization and development into a great institution, which not only is devoted to the scientific determination of weights and measurements, but has become a great physical laboratory cooperating with American industry and commerce in the solution of many problems of enormous value. Under Doctor Stratton's direction this bureau grew from a small organization of twenty-four employees in temporary quarters near the Capital to an institution with 900 workers and fourteen permanent buildings. In 1923 he resigned this position to become president of Massachusetts Institute of Technology, Cambridge, Mass., in order that he might adapt the practical and efficient methods of the bureau to what was already a leading technical school. In 1930 he was appointed chairman of the Massachusetts Institute of Technology Corporation executive board, calling Dr. Karl T. Compton, head of the department of physics at Princeton University, to be president. France made him a chevalier of the Legion of Honor in 1909, and an officer in 1928; he had received the Elliott Cresson Medal of the Franklin Institute, and the Welfare Medal of the National Academy of Sciences. He belonged to many clubs and organizations, among which were the American Society of Mechanical Engineers, the American Physical Society, the American Philosophical Society, the National Academy of Sciences, and the American Association for the Advancement of Science. He was also a member of the interdepartmental board of the Council of National Defense, and the National Advisory Committee for Aeronautics; three years ago he accepted the invitation of Secretary Wilbur to serve on the navy board named to study safety devices for submarines.

Winter Convention Plans are Announced

With the technical program for the 1932 winter convention of the Institute already essentially completed, activities and preparations for the coming event now are in full swing with the appointment by President Skinner of the general convention committee. Winter convention activities are scheduled for Jan. 25-29, 1932, with convention headquarters at the Engineering Societies Building, 33 West 39th Street, New York, N. Y.

As members of the general convention committee, Doctor Skinner has appointed the following: *chairman,* E. B. Meyer (F'27) chairman publication committee; O. H. Caldwell (M'22) chairman New York Section; H. P. Charlesworth (F'28) vice-president; Harold C. Dean (F'30) secretary New York Section; W. H. Harrison (F'31) chairman meetings and papers committee; C. R. Jones (F'31) secretary, New York City District; G. L. Knight (F'17) A.I.E.E. representative on Board of Trustees, United Engg. Trustees, Inc.; C. E. Stephens (M'22) chairman finance committee; R. H. Tapscott (F'29) chairman headquarters committee.

In planning the technical program special efforts are being made to cover the art completely during the year. Hence, on the winter convention program there surely will be several sessions on subjects which have not been presented at this annual affair during the past few years. Indications point toward the presentation of very large number of papers, some of which will be presented from the manuscript without publication, and without distribution of an advance copy. Three sessions tentatively scheduled accommodate symposiums: (1) distribution circuit lightning protection, (2) system stability, (3) time and time services. The symposium on system stability promises to be of wide general interest. It is sponsored by the joint subcommittee on interconnections which is comprised of members of the committees on power generation, power transmission and distribution, and protective devices. Other subjects tentatively under consideration for sessions are: instruments and measurements, research and general circuit theory, protective devices, electrical machinery, electric welding, communication, electrochemistry and electrometallurgy, transportation, and several selected subjects.

These plans should leave nothing to be desired from a standpoint of technical interests. Plans for the social features, entertainment and inspection trips will not be left undone and these will be announced at a later date.

Letters to the Editor

Corona and Line Surges

To the Editor:

Dr. H. H. Skilling's article "Corona and Line Surges," which appeared in the October 1931 issue of ELECTRICAL ENGINEERING, prompts me to submit a comparison between the following four different formulas for the attenuation of traveling waves:

1. Simple exponential attenuation, which is exact for the ideal transmission line in which the line "constants" R, L, G, C are true constants.
2. The Foust and Menger empirical formula, which appeared in W. W. Lewis's 1928 A.I.E.E. paper "Surge Voltage Investigation of Transmission Lines."
3. The Skilling formula, described in his article.
4. A formula based on the assumption that the corona loss for traveling waves follows the quadratic law, the derivation of which is given as an appendix to these comments.

Referring to Fig. 1, in which these four formulas have been plotted so as to pass through a common point at 50 per cent of the initial voltage of the surge, it may be seen that there are three principal regions involved:

Region I—from the initial voltage of $E = 2{,}000$ kv. to the 50 per cent voltage point of 1,000 kv.

Region II—from $e = 1{,}000$ kv. to the critical corona voltage $e_0 = 500$ kv.

Region III—below the critical corona voltage $e_0 = 500$ kv.

In region I, the Foust and Menger formula agrees almost perfectly with the quadratic formula, and Skilling's formula agrees equally well with the exponential law. The difference between these two pairs is not great, and of little practical importance. In this region of greatest interest all four formulas are of practically equal accuracy, and therefore the formula will be used which is the most convenient. The Foust and Menger formula is the most simple for estimating the attenuation, but the exponential formula is easier to operate mathematically.

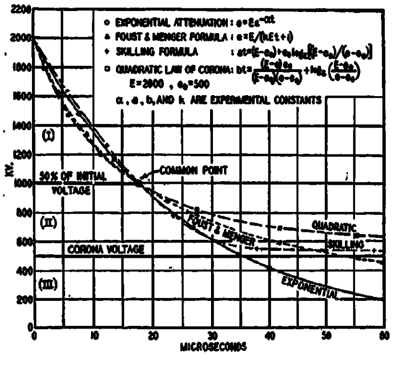


Fig. 1. Comparison of formulas for attenuation of traveling waves

In region II the Foust and Menger formula parts company with the quadratic formula, but the Skilling formula and exponential law continue to agree until the critical corona voltage is neared, when the Skilling formula abruptly flattens out while the exponential crosses to region III.

Both the Skilling and the quadratic formulas are asymptotic to the critical corona voltage, and therefore do not appear in region III. The Foust and Menger and the exponential formulas enter region II, but at widely different points and diverge considerably.

While the exponential, Skilling, and quadratic formulas, appear on the surface to have been derived by a rational process, it should be noticed that all three of them are based upon the assumption that the current and voltage waves are exact replicas of each other; in other words, the distortion is ignored. Moreover, the experimental constants α, a, b have to be determined from tests on the transmission line in question and under the actual conditions that are to prevail. Thus in this respect they are no better off than the Foust and Menger formula. The very abrupt flattening of the Skilling formula as the critical corona voltage is approached is not always evidenced by experimental data.

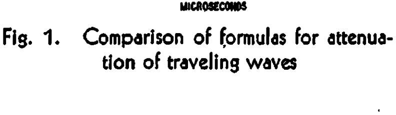


Fig. 2. A typical traveling wave f4

MATHEMATICAL EXAMPLE

Consider a traveling wave $e = f(x - vt)$ of length D, (Fig. 2) and its companion current wave i, and suppose that these two waves are related by the surge impedance:

$$e = Z\,i = \sqrt{\frac{L}{C}}\,i \tag{1}$$

At time t the toe of the wave is at $x = vt$ from the origin, and the total stored energy of the wave is

$$W = \frac{C}{2}\int_{(vt-D)}^{vt} e^2\,dx + \frac{L}{2}\int_{(vt-D)}^{vt} i^2\,ds$$

$$= C\int_{(vt-D)}^{vt} f^2(x - vt)\,dx \tag{2}$$

The rate at which the energy content is changing with respect to t is

$$\frac{dW}{dt} = C\int_{(vt-D)}^{vt} \frac{\partial}{\partial t} f^2(x - vt)\,.\,dx$$

$$+ C\,v\,f^2(vt - vt) - C\,v\,f^2(vt - D - vt)$$

$$= C\int_{(vt-D)}^{vt} \frac{\partial}{\partial t} f^2(x - vt)\,.\,dx$$

$$= C\int_{(vt-D)}^{vt} \frac{\partial e^2}{\partial t}\,dx \tag{3}$$

because $f(0) = 0$ and $f(-D) = 0$

Now if the rate of energy dissipation due to the line losses is a function of the voltage $\phi(e)$, then the total rate of energy loss for the entire wave is

$$\int_{(vt-D)}^{vt} \phi(e)\,.\,dx \tag{4}$$

Equating (3) and (4) and discarding the integrals

$$C\frac{\partial e^2}{\partial t} = -\phi(e) \tag{5}$$

subject to the initial conditions

$$e = E(x) \text{ at } t = 0 \tag{6}$$

The solution of (5) thus defines the wave at any instant t. By way of illustration, three special cases will be considered.

CASE I—Ideal Transmission Line.—Such a line is characterized by four line constants R, L, C, G and if eq. 1 holds, the rate of energy loss is

$$\phi(e) = R\,i + G\,e^2 = R\frac{C}{L}e^2 + G\,e^2$$

$$= \left(\frac{RC + LG}{L}\right)e^2 \tag{7}$$

Substituting (7) in (5) and using (6) this results in

$$e = E\,\epsilon^{-\alpha t} \text{ where } \alpha = \frac{1}{2}\left(\frac{R}{L} + \frac{G}{C}\right) \tag{9}$$

CASE II—The Skilling Formula.—If the loss is assumed to vary as the excess voltage above the critical corona voltage e_0, then

$$\phi(e) = -k(e - e_0) \tag{10}$$

and (5) and (6) give

$$\frac{k}{2C}t = a\,t = (E - e) + e_0\log\left(\frac{E - e_0}{e - e_0}\right). \tag{11}$$

CASE III—The Quadratic Formula.—If the loss is assumed to vary as the square of the excess voltage above the critical corona voltage, then

$$\phi(e) = -K(e - e_0)^2 \qquad (12)$$

Then by (5) and (6)

$$\frac{Kt}{2C} = \frac{(E - e)\,e_0}{(E - e_0)\,(e - e_0)} + \log\frac{(E - e_0)}{(E - e_0)} \qquad (13)$$

I have in the past devoted a considerable part of my time to the study of traveling waves, and feel that the attenuation of surges is the most important thing left to be found out about traveling waves. I think that you will serve the industry by keeping the subject alive by continuing to print articles like Doctor Skilling's, and inviting discussion.

Yours very truly,
L. V. BEWLEY (A'27)
(General Transformer Engg. Dept., General Electric Co., Pittsfield, Mass.)

A Note on Symmetrical Components

To the Editor:

I am submitting herewith a short discussion on symmetrical components which is intended to be an addition to Dr. A. E. Kennelly's article "Computation of the Unbalance Factor of a Three-Phase Triangle When Lengths of Three Sides are Given" which appeared in the JOURNAL of the A.I.E.E., March 1927, p. 240.

In his article Doctor Kennelly develops formulas for computing the magnitude of the direct and reverse sequence components, when given the lengths of the three sides of the voltage triangle. In this discussion I develop a simple formula for the angle between the direct and reverse sequence components, the expression being in terms of the lengths of the sides of the voltage triangle.

In his article Doctor Kennelly gave (the mathematical equivalent of) the following expressions for computing the forward (positive phase or direct sequence) and backward (negative phase or reverse sequence) components of a dissymetric three-phase vector triangle:

$$d^2 = \frac{\dfrac{a^2 + b^2 + c^2}{3} + S^2}{2}$$

and

$$r^2 = \frac{\dfrac{a^2 + b^2 + c^2}{3} - S^2}{2}$$

where a, b, and c are the lengths of the vectors forming the triangle and S (A_s in Doctor Kennelly's article) is the side of an equilateral triangle having the same area as triangle $a\,b\,c$; d and r (e in Doctor Kennelly's article) are, respectively, the magnitudes of the direct and reverse sequence components.

It is the object of this note to obtain an additional expression for the angle between d and r in terms of a^2, b^2, and c^2, terms used in Doctor Kennelly's expressions.

Let the vector representation of a, b, and c be

$$a = d_a + r_a = d\,j\,0^0 + r\,j\,\theta_a \qquad (1)$$

$$b = d_b + r_b = d\,j\,240^0 + r\,j\,(120^0 + \theta_a) \qquad (2)$$

$$c = d_c + r_c = d\,j\,120^0 + r\,j\,(240^0 + \theta_a). \qquad (3)$$

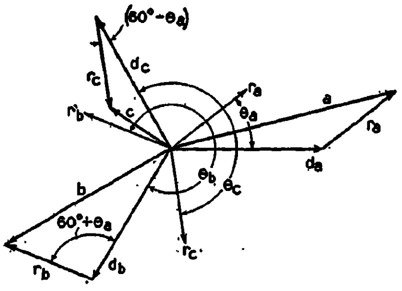
This is quite evident from the accompanying illustration.

By the law of cosines

$$b^2 = d^2 + r^2 - 2\,d\,r\cos(60^0 + \theta_a)$$

and

$$c^2 = d^2 + r^2 - 2\,d\,r\cos(60^0 - \theta_a)$$



Vector relations in an unbalanced three-phase system with direct and reverse sequence components

so that

$$\cos(60^0 + \theta_a) = \frac{d^2 + r^2 - b^2}{2\,d\,r}$$

$$= \frac{\cos\theta_a}{2} - \frac{\sqrt{3}\sin\theta_a}{2} \qquad (4)$$

$$\cos(60^0 - \theta_a) = \frac{d^2 + r^2 - c^2}{2\,d\,r}$$

$$= \frac{\cos\theta_a}{2} + \frac{\sqrt{3}\sin\theta_a}{2} \qquad (5)$$

Subtracting eq. 4 from eq. 5

$$\frac{b^2 - c^2}{2\sqrt{3}\,d\,r} = \sin\theta_a \qquad (6)$$

Adding eq. 4 and eq. 5

$$\frac{2\,d^2 + 2\,r^2 - b^2 - c^2}{2\,d\,r} = \cos\theta_a \qquad (7)$$

But by making use of Doctor Kennelly's expressions for d and r in terms of a, b, and c, eq. 7 can be changed to

$$\frac{2\,a^2 - b^2 - c^2}{6\,d\,r} = \cos\theta_a \qquad (8)$$

Eq. 6 must be divided by eq. 8 to obtain the final expression

$$\tan\theta_a = \frac{\sqrt{3}\,(b^2 - c^2)}{2\,a^2 - b^2 - c^2}$$

or

$$\theta_a = \arctan\frac{\sqrt{3}\,(b^2 - c^2)}{2\,a^2 - b^2 - c^2} \qquad (9)$$

If use is made of Doctor Kennelly's expressions for d and r, the extra labor required to obtain θ_a will be small since a^2, b^2, and c^2 occur in both expressions.

Assuming the same values which Doctor Kennelly used in his example, let

a = 1,100 volts
b = 1,000 volts
c = 900 volts whence
d = 996.61 volts and
r = 115.91 volts

Using the final eq. 9

$$\theta_a = \arctan\frac{+19\sqrt{3}}{+61} = +28^0\,20'$$

It is interesting to note that by a cyclical interchange of the terms in the expression for θ_a, expressions for θ_b and θ_c can be obtained as follows:

$$\theta_b = \arctan\frac{\sqrt{3}\,(c^2 - a^2)}{2\,b^2 - c^2 - a^2}$$

$$\theta_c = \arctan\frac{\sqrt{3}\,(a^2 - b^2)}{2\,c^2 - a^2 - b^2}$$

Substituting in these expressions for θ_b and θ_c the values for a = 1,100, b = 1,000, and c = 900 volts, θ_b and θ_c can be obtained.

Thus

$$\theta_b = \arctan\frac{-\sqrt{3}\,(40)}{-2} = +268^0\,20'$$

$$= +240^0 + \theta_a$$

and

$$\theta_c = \arctan\frac{+\sqrt{3}\,(21)}{-59} = +148^0\,20'$$

$$= +120^0 + \theta_a$$

Hence for a given voltage triangle of arbitrarily designated sides a, b, and c, θ_a will be the smallest angle, if a is made to represent the longest side of the given voltage triangle.

Very truly yours,
E. DE LA GARZA,
(Senior Student, 1931, Rice Institute,
Houston, Texas)

Editor's Note: In commenting upon this discussion Doctor Kennelly stated that, "Mr. de la Garza's note supplies an important element not covered by my 1927 article; namely, the computed phase relation between the two symmetrical-component machines, *i. e.*, the angle at which each should be clamped on the same rotor shaft in such a way that the two symmetrical systems, electrically connected in opposite directions, would produce identically the same dissymmetrical voltages as the actual dissymmetrical machine provides."

Has Man Benefited by Engineering Progress?

To the Editor:

I assume the invitation to comment on the articles so far published in the symposium "Has Man Benefited By Engineering Progress?" (ELECTRICAL ENGINEERING, Aug. 1931, *et. seq.*) applies also to the general subject and its implications, which constitute a challenge to all of us.

The belief that engineering progress does benefit man has been widely held, otherwise there would be few engineers. It is significant that the question of "benefit" becomes of particular interest during a depression, a phenomenon the recurrence of which recently was considered most improbable. However, depressions or their equivalent occurred long before engineering attained its present stature, so it is evident that engineering is only one of the many factors in the present situation.

The most important factor and the least studied is man himself. The general lack of knowledge regarding the basic human impulses and their significance is most unfortunate. One reason for this is the unpalatability of some of the available facts.

Difficulties in the way of dealing frankly with human impulses are analogous to those encountered by the early scientists in their endeavor to substitute natural law for the popular "supernatural whim" as an explanation of physical phenomena. Modern scientists and engineers do not encounter such serious opposition, but they too are obliged to revise frequently their pet theories to fit the facts, a somewhat painful process which should aid them in dealing with the human factor.

I contend we will never reach a satisfactory basis for human relations until the available knowledge of human beings is more widely diffused. If we are unable to deal adequately with the most important factor, we should not complain when the partial solutions otherwise obtained prove ineffective.

Sincerely yours,
C. T. WELLER (A'20-M'21)
(Electrical Engineer, General Engineering Laboratory, General Electric Company, Schenectady, New York)

Col. R. E. B. Crompton, now in his eighty-seventh year and distinguished for his pioneer work in the British electrical engineering industry, was internationally honored in London by a gathering of scientists presided over by his partner, Frank Parkinson, who described Colonel Crompton as the "grand old man of the British electrical industry." He was eulogized further by Prof. Luigi Lombardi of Italy, and by a toast of the entire electrical industry proposed by the principal American guest, Dr. A. E. Kennelly, of Harvard University, past-president of the Institute.

Personal

Dr. Michael I. Pupin Awarded John Fritz Medal

Michael Idvorsky Pupin (A'90, F'15, HM'28) past-president of the Institute and professor emeritus of electrical engineering at Columbia University, N. Y., has been selected as the recipient of the 1931 John Fritz Gold Medal. The award was made to him as a leading scientist, engineer, and author, and as inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils. The John Fritz Medal is the highest honor given by engineers of the United States and was awarded to Doctor Pupin unanimously by the joint board of sixteen prominent engineers representing the four Founder Societies and their aggregate membership of more than 60,000.

M. I. PUPIN

Doctor Pupin is professor of electromechanics and director of the Phoenix Research Laboratory at Columbia University, and of course is widely known for his contributions to long distance communication and for his advanced work in electrical resonance, the passage of electricity through gases, and many other scientific subjects. To many thousands of persons the fascinating story of his life has been made known through his inimitable autobiography "From Immigrant to Inventor" and his other writings. He was born a Serb in a Hungarian province Oct. 4, 1858. He came to America as a youngster and after courageous struggles won an opportunity for an education; was graduated from Columbia University in 1883. Thereafter he studied further and received a degree of doctor of philosophy from the University of Berlin; subsequently was granted his doctor of science degree by both Columbia and Princeton universities, and his doctor of laws degree by Johns Hopkins and New York universities, Muhlenberg College, and other educational institutions. He is a past-chairman of The Engineering Foundation and his affiliations include the American Association for the Advancement of Science, National Academy of Sciences, New York Academy of Science, American Philosophical Society, American Physical Society, and other learned organizations. During the World War he served on the National Advisory Committee for Aeronautics, and many other bodies doing scientific research for the government. Doctor Pupin's other honors include the Edison Medal of the A.I.E.E., and the Carson Gold Medal of the Franklin Institute. Among earlier recipients of the John Fritz Medal are Admiral David Watson Taylor (retired) of the U. S. Navy, President Herbert Hoover, Ralph Modjeski, John J. Carty, John F. Stevens, Ambrose Swasey, Guglielmo Marconi, Sir Robert Hadfield, Charles P. E. Schneider, and Elihu Thomson.

André E. Blondel (HM'12) professor at l'Ecole Nationale des Ponts et Chaussées, Paris, France, received certificate of Honorary Membership in the Illuminating Engineering Society at a special Silver Anniversary session held in Pittsburgh, Pa., October 14, 1931. The certificate was presented "in recognition of his contribution to science and the art of illumination as educator, scientist, engineer and inventor in the scientific design of light-distribution glassware, originator of great improvements in arc lights and of methods and apparatus for photometrical measurements; author of many memoirs on the theory and practise of illumination and of the units of measurement applicable thereto. A man whose courage has enabled him to overcome most formidable physical handicaps and whose knowledge and sympathy are of international scope." The certificate itself a masterpiece of artistic workmanship, together with its purport, made an especially suitable award for Mr. Blondel's achievements in the fields of professional art and science.

Dwight P. Robinson (F'13) has resigned from the presidency of United Engineers & Constructors, Inc., Philadelphia, Pa., having completed his work of coordination of the activities of the United Gas Improvement Contracting Company, Day & Zimmermann Engineering & Construction Company, the Public Service Production Company, and Dwight P. Robinson & Company, Inc. He is succeeded by E. M. Chance, vice-president. For over forty years identified with organizing and administrative work on outstanding construction enterprises, Mr. Robinson is a well-known figure in today's engineering field. His achievements with the Stone & Webster organization as well as the wealth of experience which he has acquired in the operation of its subsidiaries as early as 1913 placed him in the front ranks of the profession. His field of application has never been restricted one; in addition to his activities in electrical construction, he was, from 1913 to 1917 consulting chemist and engineer for anthracite and bituminous coal mining companies in Pennsylvania and West Virginia.

Elihu Thomson (F'13-HM'28) charter member and past-president of the Institute, on October 14 at a special session of the Illuminating Engineering Society's Silver Anniversary convention, Pittsburgh, Pa., had honorary membership in the I.E.S. bestowed upon him, "in recognition of his contribution to science and the art of illumination as an educator, scientist, engineer and inventor; distinguished as a pioneer in electric lighting and in the development of electric arts; in recent years renowned through his contributions to the technology of quartz and its application to illumination problems, particularly the preparation of specula of hitherto unattained dimensions; the recipient of many honors at home and abroad and beloved by all who know him."

President Skinner (F'12) recently was the guest speaker at the Silver Anniversary convention of the Illuminating Engineering Society, held in Pittsburgh, Pa., October 13-16, 1931. His address delivered at the special Silver Anniversary session which took place Wednesday evening briefly and interestingly sketched the "progress of illumination" from the time when he first saw an electric light, at a traveling circus, through the period of transformation twenty-five years had accomplished "to the point where it is equal in its efficiency to daylight." He also spoke of the use of illumination "as an artistic expression to such an extent that buildings, parks, and fountains become things of beauty after the night has fallen."

G. H. Harries (F'22) major-general U. S. A. (retired) formerly vice-president for H. M. Byllesby & Company, Chicago, Ill., and for nearly forty years representative of investors, operators, estimators and consumers of electric energy throughout the country, now has retired from the active engineering field. General Harries at various consecutive periods, has been treasurer of the National Electric Light Association, and president of the Association of Edison Illuminating Companies, the American Electric Railway Association and the Illumination Engineering Association. Upon retirement he has chosen Los Angeles, Calif. as a place of residence.

Lyman Winn (A'30) who has been doing sales engineering work with the Shelby Electric Company at Memhpis, Tenn., recently joined the engineering force of the Standard Electric Company there in like capacity. Mr. Winn was a member of the committee which wrote the constitution and by-laws of the Institute's Memphis section; he also has contributed to technical literature through the columns of *Mill & Factory*, an Illinois publication.

H. H. Anderson (M'27) who was engineer of special investigations for the Shell Oil Company, San Francisco, Calif., now is assistant to the president of the Shell Union Oil Corporation, New York, N. Y. Mr. Anderson was at one time a member of the executive committee of the division of development and production engineering of the American Petroleum Institute, and has published a number of technical articles in that field.

A. E. Kennelly, (F'13) professor emeritus of electrical engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass., has gone to Japan. At the invitation of the Institution of Electrical Engineers of Japan, he will deliver a group of lectures during November before five Japanese universities as the first visiting American professor under the Iwadare Foundation.

E. R. Davis (A'09) who has been manager of construction for the Southern California Edison Company, Ltd., Los Angeles, now has assumed additional duties as its manager of construction and engineering with executive supervision of both of these departments. Coincident with his new appointment his company has organized an engineering executive committee with Mr. Davis as a member.

T. H. MORGAN

T. H. Morgan (A'23) who has been assistant professor of electrical engineering, secretary of the electrical engineering faculty and assistant to the executive head of the department, at Stanford University, now has been called East to occupy the position vacated by Prof. H. B. Smith, head of the department of electrical engineering at Worcester Polytechnic Institute, Worcester, Mass. Professor Morgan, who is a native of Fredericton, New Brunswick, Can., received his early technical training at the University of British Columbia (1913-16), Stanford University (1917-1919-1920) followed by postgraduate studies in electrical engineering there (1928-1929). Before becoming assistant professor at Stanford University he was for four years an instructor. He has had also extensive practical experience in the superintendency of the Foundation Company, Victoria, B. C., as test engineer of the Inspiration Consolidated Copper Company, Arizona, and as engineer of the Great Western Power Company, San Francisco, Calif. In 1927 he was secretary of the electrical engineering faculty of Stanford University, counselor of the Stanford A.I.E.E. Branch, chairman of the committee on Student activities as well as of the committee on prizes and awards of the 8th District in 1929. Prof. Morgan is a member of the Society for the Promotion of Engineering Education, and a liberal contributor to technical literature.

C. W. Rice (F'12) secretary of the American Society of Mechanical Engineers, New York, N. Y., has been honored by Verein Deutscher Ingenieure at its 75th anniversary meeting in Cologne, when he was the recipient of its medal "in grateful appreciation of services to technical-scientific achievement, particularly in promoting mutual international interests."

A. V. Guillou (M'27) has resigned from the position as assistant chief engineer of the California Railroad Commission after four years of service in that position. He will now function as chief engineer for the newly formed Public Service Commission of Wisconsin. Mr. Guillou is well known in his work with the various power companies of California.

M. K. McGrath (M'27) vice-president of the International Telephone & Telegraph Corporation whose change of residence from London, England, to New York, N. Y. was posted in the July 1931 issue of Electrical Engineering, now is located with the Postal Telegraph-Cable Company in Chicago, Ill.

A. G. Ennis (A'31) who was engineering assistant in the mechanical department of the Philadelphia & Reading Coal & Iron Company, now is identified with the George Washington University, Washington, D. C., in the capacity of instructor in the electrical engineering department.

W. B. Massenburg (A'31) of Warrenton, N. C., recently has made new connections with the Westinghouse Electric & Manufacturing Company, at Philadelphia, Pa. He was at one time associated with the home office at East Pittsburgh, Pa., in the sales engineering department.

E. N. Willis (M'28) executive secretary of the University Club at Dallas, Texas, and at one time branch manager of the New Orleans branch of the Auto Men's Association, has opened his own business offices in the Electrified Ozone Water Company, Brownsville, Texas.

Winthrop Allen (A'30) who has been working with E. I. du Pont de Nemours Company, Wilmington, Del. as assistant electrical engineer now has associated himself with the Prudential Insurance Company, Newark, N. J., as electrical engineer of home office buildings.

C. L. Edgar (F'12) president and general manager of the Edison Electric Illuminating Company of Boston, recently was chosen chairman of the executive committee of the Society for Electrical Development. He already has served this society as president.

A. J. Grant (A'26) of the meter engineering department, Westinghouse Electric & Manufacturing Company, Newark, N. J., has removed to Ottawa, Ontario, Canada, where he will assume new duties in the physics department of the National Research Council.

C. E. Allen (F'14) previously southwest district manager for the Westinghouse Electric & Manufacturing Company, St. Louis, Mo., and subsequently at the East Pittsburgh works, now is located at Mansfield, Ohio, works of this company.

A. W. Manby (A'22) who was chief operator at the Queenston generating station of the Hydro-Electric Power Commission of Ontario, Niagara Falls, N. Y., has been transferred to its new Chats Falls plant, Fitzroy Harbour, Ontario.

William Shuler (M'24) who has been serving the Columbia Engineering & Management Corporation, Cincinnati, Ohio, as its electrical engineer now has made new connections with the Dayton Power & Light Company, Dayton, Ohio.

P. A. deMars (M'31) who was previously professor of electrical engineering at Tufts College as well as consulting engineer, Boston, Mass., recently was chosen technical director of the Shepard Broadcasting Service, Inc., in that city.

O. W. Walter (M'29) research engineer, Hall Electric Heating Company, Inc., Philadelphia, Pa., now is assistant professor in electrical engineering at The College of the City of New York and is residing at Hastings-on-Hudson.

W. Viessman (M'29) mechanical and electrical engineer, Bureau of Mechanical and Electrical Service, City of Baltimore, Md. now is engaged in an industrial consultant service of his own as mechanical-electrical engineer in that city.

R. L. Cotton (A'30) junior engineer with the New York Edison Company, New York, N. Y., has made new affiliations with the American Radio News Corporation, New York, N. Y., which he will serve as station engineer.

C. E. Crofoot (M'28) who previously was in the technical high school department of the Utica Free Academy, Utica, New York, now is in the technical school department of the Mount Pleasant High School, Schenectady, N. Y.

W. W. Macalpine (A'30) who has been radio engineer for the International Communication Laboratories, Mount Vernon, N. Y., has been chosen director of research, Communication Patents, Incorporated, at Ampere, N. J.

M. B. Wyman (A'30) who for some time was central station engineer of the general engineering department, Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa., now h s removed to this company's office at St. Louis, Mo.

A. J. Bronold (A'29) sales assistant of the Westinghouse Electric & Manufacturing Company's specialist group, Pittsburgh, Pa., has made recent affiliations with the Westinghouse Lamp Company, at Columbus, Ohio.

A. B. Chapman (A'29) who for some time has been serving the RCA Victor Company, Incorporated, as service engineer at Oklahoma City, Okla., now has taken up new work for that company at Dallas, Texas.

W. M. Young (A'24) of the department of electrical engineering, University of Iowa, Iowa City, Ia., has joined the engineering research department of the Taylor Instrument Company, Rochester, N. Y.

H. A. Barre (A'11) chief engineer of the Southern California Edison Company, Ltd., Los Angeles, serves with E. R. Davis on the recently created engineering executive committee of that organization.

H. B. Briggs, Jr. (A'30) who has been located in New York, N. Y. as electrical engineer for Theodore E. Ferris, has accepted position with the Bath Iron Works Corporation, at Bath, Me.

E. A. Preisel (A'30) who has been switchboard draftsman for the Westinghouse Elec. & Mfg. Company, Buffalo, N. Y., now has joined that company's forces at Newark, New Jersey.

H. Romander (A'28) engineer, Federal Telegraph Company, Palo Alto, Calif., has removed to Newark, N. J., where he will serve the Federal company in the capacity of radio engineer.

A. D. Pettee (A'20) consulting engineer for the General Cable Corporation at Perth Amboy, N. J., now is consulting engineer for accessories at the Chicago office of the corporation.

H. E. Gumbart (A'25) who was serving as division sales engineer for the Brown Company, Chicago, Ill., now has been transferred to the company's office at Portland, Maine.

G. K. Morrison (A'23) electrical engineer, Federal Telegraph Company, Palo Alto, Calif., has removed to Newark, N. J. where he is still serving this company.

S. L. Poohar (A'31) field service engineer for the RCA Photophone, Inc., Atlanta, Ga., has been transferred to that company's offices at Irwin, Pa.

J. S. Mahan (F'27) field engineer of Steel & Tubes, Inc., Chicago, Ill., now is serving Electrotrim, Incorporated, of that city, in like capacity.

Hugh Skilling (A'28) of San Diego, Calif., has removed to Stanford University, Calif., for university work there.

Obituary

Garnett Holstein Finks (A'16) engineer of the power sales division of the Alabama Power Company, Birmingham, Ala., with which he had been associated since 1922, died at his home September 18, 1931, of pneumonia. He was born at Bertha, Va., July 20, 1891, was a student in electrical engineering at the Virginia Polytechnic Institute, and immediately thereafter engaged in machine shop practise and general construction with the Mathieson Alkali Works. During the period 1912-1913 he was in the electrical departments of the Norfolk and Western Railway, where he was called upon to study a multiplicity of electrical application. In the subsequent position of chief electrician for the Gilliam Coal and Coke Company, the Arlington Coal and Coke Company, the Shawnee Coal and Coke Company and the Glen Alum Coal Company (in advisory capacity) he was given charge of all of their electrical and mechanical work involving maintenance and construction of power plants and machine shops. This was his position until he joined the U. S. government forces at the Hog Island Shipyard, thence to be transferred to the government aviation department at League Island. Shortly after the close of the war, Mr. Finks became connected with the Mill & Mine Engineers, at Birmingham, Ala., which led in 1922 to his being chosen power engineer of the sales department of the Alabama Power Company, his last position.

Harold Calvert (A'17) consulting engineer with the firm Calvert & Barnes, Philadelphia, Pa., died June 27, 1931, in Philadelphia, the city of his birth. He was born April 7, 1875. He attended the University of Pennsylvania, graduating in 1893 with the degree of B. S. in E. E.; in 1897 he obtained his E. E. degree from this same university. His first work in the practical field of electricity was on storage battery installations and switchboard design, in the drafting department of the Electric Storage Battery Company of Philadelphia. In 1900 he became draftsman for the firm of McIntosh & Seymour, Auburn, N. J., on engine design, and two years later he joined the Philadelphia Electric Company as draftsman on station design; later becoming inspector on station construction, and still later made estimating engineer for the writing of wiring specifications for light and power. From this work Mr. Calvert was promoted again to the charge of design and inspection of customers' installations, later forming his own company. In this practise Mr. Calvert but emphasized his already established reputation as a worthy consultant.

Gifford LeClear (A'97-M'28) prominent member of the engineering firm of Densmore, LeClear & Robbins, Boston, Mass., died at his home in Waban, Mass., September 24, 1931, at the age of 57. He was a native of Rutherford, N. J. He won his A. B. degree from Harvard University in 1895 and his A. M. in 1896. For three years he was assistant professor of physics at Harvard, later obtaining practical experience with the West End Street Railway. In 1898 his own company was formed, first as Densmore & LeClear and later as Densmore, LeClear & Robbins, architects and engineers. Mr. LeClear took charge of the electrical work. As an engineer he enjoyed a national reputation; his design and engineering skill is associated with the erection of the Harvard Medical School group of buildings in Boston, and for many years his genius was called upon for similar institutional work in this locality. He also served on a committee which laid out a comprehensive traffic signal system for the city of Boston. Many of this city's latest and most modern buildings are products of his ingenuity. He was one of the leading spirits of the city.

Joseph Bijur (A'94-F'13) president of the Bijur Lubricating Corporation, New York City, and Life Member of the Institute, died suddenly October 19, 1931.

Oliver Jackson Bushnell (M'19) superintendent of the meter department of the Commonwealth Edison Company, Chicago, Ill., died recently at his home in Hinsdale, Ill. He was born at Rockton, Ill., September 13, 1871. Shortly after being graduated from a classical course at Beloit College, he entered the employ of the Chicago Edison Company, and in 1895 was appointed superintendent of the meter department. As a member and later chairman of the meter committee of the Association of Edison Illuminating Companies he assisted in the preparation of the meter code; and as chairman of the N.E.L.A. meter committee, he instituted and supervised the preparation and publication of the Electrical Meterman's Handbook. In 1919 he joined the Commonwealth Edison Company to take direct charge of the customers' meter engineering including the 80,000 demand meters of the company. Only recently he was appointed to the committee of advisors on measuring instruments of the United States national committee of the International Electrotechnical Commission.

Cyril Thomas Wall (A'31) of St. Paul, Minn., died August 22, 1931. He was born at Evansville, Ind., March 30, 1906, and was student equipment engineer for the Northwestern Bell Telephone Co., chief engineer's department, Minneapolis, Minn. His degree of Bachelor of E. E. was conferred upon him by the University of Minnesota, June 1930.

Local Meetings

District 6 Executive Committee Meets at Omaha

On Sept. 28, 1931, the executive committee for the Institute's North Central District met in the Telephone Building at Omaha, Neb. Present were P. H. Patton (Omaha) District vice-president; N. R. Love and Dr. R. E. Nyswander of the Denver Section; H. F. Rice of Grand Forks, N. D.; A. L. Turner (Omaha) and Clarence Talsma (Omaha) of the Nebraska Section; and C. E. Skinner, president of the Institute.

Following Doctor Skinner's informal talk about Institute policies and problems, the committee turned to its routine business electing Vice-President Patton as District delegate on the national nominating committee, with A. L. Turner as an alternate. To serve on the District prize awards committee, H. S. Sands of Denver was appointed chairman of a committee to consist of himself, A. L. Jones of Denver, and C. D. Robison of Omaha.

Ways and means were discussed of stimulating greater participation in Institute affairs by both Members and Enrolled Students. It is contemplated that efforts will be made to stimulate the preparation and presentation of more papers by both Section members and students, so that there may be a larger number of papers available for prize competition. It was urged also that qualified persons contemplating trips through the District should be encouraged to arrange stop-overs in order to permit them to address the Student Branches particularly those farther removed from the headquarters of the District's two sections. In this connection also was mentioned the success attending the Denver Section's practise of holding its annual business meeting on the campus of the University of Colorado (Boulder) in cooperation with the students "engineers' day" activities.

District 2 Executive Committee Meets at Pittsburgh

To transact matters of routine business and to plan for future District meetings, the executive committee of the Institute's Middle Eastern District met at the Keystone Athletic Club, Pittsburgh, Pa., Sept. 15, 1931. Representatives present were: *vice-president*, W. B. Kouwenhoven (Baltimore, Md.); *secretary*, G. S. Diehl (Baltimore, Md.); *assistant national secretary*, H. H. Henline (New York); *Section chairmen*, R. R. Krammes (Akron, Ohio); K. A. Hawley (Baltimore, Md.); E. S. Fields (Cincinnati, Ohio); G. A. Kositzky (Cleveland, Ohio); P. R. Urich (Erie, Pa.); Morland King (Lehigh Valley); F. A. Connor (Pittsburgh, Pa.); R. M. Field (Sharon, Pa.); J. A. Dinwiddie (Toledo, Ohio); G. L. Weller (Washington, D. C.); *Section secretaries*,

R. A. Hudson (Akron, Ohio); John Wells (Baltimore, Md.); J. A. Noertker (Cincinnati, Ohio); F. E. Snell (Cleveland, Ohio); R. Mallory (Columbus, Ohio); C. V. Roberts (Erie, Pa.); J. L. MacBurney (Philadelphia, Pa.); T. Spooner (Pittsburgh, Pa.); *alternate for secretary,* F. R. Mueller (Washington, D. C.).

As District representative on the national nominating committee, F. J. Chesterman (A'20-F'22) of Pittsburgh, Pa., was elected and authorized to go uninstructed. As members of the District coordinating committee, in addition to the District vice-president and secretary, K. A. Hawley (Baltimore, Md.) G. L. Weller (Washington, D. C.) F. A. Connor (Pittsburgh, Pa.) and C. N. Johnson (Philadelphia, Pa.), Section officers, and Prof. J. T. Walther (Akron, Ohio) as student Branch counselor, were elected. To round out the District meeting committee, which is composed of the district coordinating committee and two members from the Section where the next proposed District meeting is to be held, K. A. Hawley, chairman of the Baltimore Section, appointed A. F. Bang and L. G. Smith.

To serve District No. 2 as a prize award committee, Dr. M. G. Lloyd, Washington, D. C., was elected to serve as chairman, along with Prof. T. D. Owens, (Cleveland, Ohio) and W. A. Hillebrand (Barberton, Ohio).

The District committee is planning for a 1932 fall District meeting to be held in Baltimore, and contemplates the possibility of a District meeting at Akron, Ohio, for the spring of 1933. Ways and means of stimulating Section activities were discussed and the desirability of pursuing unrelenting membership activities was emphasized.

N. Y. Section to Hear About Suburban Electrification

Suburban electrification will be the topic for discussion at a meeting to be held at 7:30 p. m. on Tuesday, November 10, 1931, in Room 1 of the Engineering Societies Building, 33 West 39 Street, New York, N. Y., by the Transportation Group of the Institute's New York Section.

G. A. Wright of the Reading Company will give a talk on the Reading electrification, describing the construction and illustrating with moving pictures the interesting steps leading up to inauguration of service.

R. M. White of the Delaware, Lackawanna & Western Railroad will outline the experiences of a railroad which has for the past year operated suburban traffic under electric power.

Future Section Meetings

Akron

November 10, 1931—Oil Purification, by R. P. Dunmire, Buckeye Laboratories, Inc.

December 8, 1931—Television, by J. O. Perrine, American Tel. & Tel. Co.

Cleveland

November 19, 1931—Engineering in Russia, by Arthur G. McKee, President, Arthur G. McKee & Co.

December 17, 1931—Behind the Scenes, by Dr. Zay Jeffries, metallurgical engineer and consultant; W. L. Enfield, manager, incandescent lamp development laboratory. Both of these speakers are with the General Electric Company at Nela Park. Joint meeting with the Illuminating Engineering Society.

Dallas

November 23, 1931—Communications, by H. S. Osborne, American Tel. & Tel. Co.

Detroit-Ann Arbor

November 10, 1931—Power System Stability, by Robert Treat, General Electric Company. Meeting to be held at Jackson, Mich.

December 1, 1931—Subject to be announced later. Meeting to be held at Detroit Edison Auditorium.

Lehigh Valley

November 13, 1931—Power System Operation, by George M. Keenan, superintendent of the Pennsylvania-New Jersey 220-kv. Interconnection. Arrangements have also been made to visit and inspect the Service Depot of the Metropolitan Edison Co. in Reading.

Pittsburgh

November 10, 1931—Lightning Protection of Overhead Transmission Systems, by W. W. Lewis, General Electric Co.

December 8, 1931—Recent Developments in Electrical Research, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co.

Rochester

November 9, 1931—Experimental Visual Broadcasting, by A. B. Chamberlain, Columbia Broadcasting System;

Advances in Ultra Short Wave Transmission and Reception, by Edward Karplus, General Radio Co. Joint meeting with the I. R. E.

Toledo

November 20, 1931—Power Transformer Design and Tap Changing Under Load, by L. H. Hill, Allis Chalmers Mfg. Co.

Talk by James Dinwiddie, Westinghouse Electric & Mfg. Co.

December 9, 1931—Television, Its Fundamental, Physical and Psychological Principles, by J. O. Perrine, American Tel. & Tel. Co.;

Protective Relays, by J. H. Hunt, Toledo Edison Co.

Past Section Meetings

Boston

Inspection trip through the new Herald-Traveler Building. October 3. Attendance 300.

Chicago

Industrial Russia, by John M. Carmody, editor, Factory & Industrial Management. Dinner preceded the meeting. Joint meeting with the Western Society of Engineers and the A.S.M.E. September 21. Attendance 650.

Cincinnati

Lighting for Health—Latest Types of Equipment and Methods of Application, by Carl E. Egeler, General Electric Co. Dinner preceded the meeting. September 10. Attendance 62.

Dallas

The Use of Electricity and Radiant Energy in Medicine, by Dr. Charles L. Martin. Illustrated with slides, charts, and demonstrations. September 26. Attendance 81.

Denver

Demonstration of Induction Between Power and Telephone Circuits, by H. R. Huntley, American Tel. & Tel. Co. September 9. Attendance 205.

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. Doctor Skinner showed motion pictures which he had taken during his recent world tour. Dinner preceded the meeting. September 25. Attendance 15.

Detroit-Ann Arbor

Aviation, by William B. Stout, Stout Engineering Laboratories. Mr. Stout described some of the difficulties which have been met in developing commercial aviation. Annual dinner meeting. September 15. Attendance 150.

Erie

Unemployment from Technological Standpoint, by Laurence A. Hawkins, General Electric Company. September 15. Attendance 75.

Houston

Production and Application of Light, by V. O. Clements, Westinghouse Electric & Mfg. Co.;

Electrical Equipment for Oil Field Operation, by I. T. Hockaday, General Electric Co.;

The Responsibility of Members of the A.I.E.E. to Their Local Section, by J. E. Sheehan, Houston Lighting & Power Co.;

Résumé of Lightning Protection on Transmission Lines, by E. J. Shimek, Rice Institute. The above papers were taken from articles published in Electrical Engineering and each was presented in approximately twenty minutes. Dinner preceded the meeting. September 17. Attendance 30.

Los Angeles

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co.;

An Electrical Engineer's Part in Aviation, by C. F. Green, General Electric Co. Past-chairman H. W. Hitchcock and chairman P. S. Biegler gave brief reports of the Asheville and Lake Tahoe conventions, respectively. Dinner preceded the meeting. September 8. Attendance 96.

Louisville

Recreational meeting. September 25. Attendance 69.

Memphis

Tata Hydroelectric Development in West India, by M. Eldredge, Memphis Power & Light Co. September 8. Attendance 48.

Mexico

Dinner meeting at which the officers for the term 1931-32 were announced as follows: E. F. Lopez, chairman; L. Castro, secretary; F. Aubert, treasurer. September 22. Attendance 40.

Minnesota

A. A. Kearney, Manilla Electric Lighting & Power Co., gave a talk on interesting phases of his experiences in the Orient. September 22. Attendance 44.

Niagara Frontier

Some Engineering Features of the Niagara-Hudson System, by Norman R. Gibson, Niagara-Hudson Power Co.;

The New 60-Cycle Distribution System in Buffalo, by R. T. Henry, Buffalo, Niagara & Eastern Power Corp. Dinner was held at the Hotel Statler preceding the meeting. September 18. Attendance 120.

Oklahoma City

Taping of High Voltage Cable Joints, by R. Schaeffer, Byllesby Engineering & Mgt. Corp.;

Piloted Ground Wire Study, by J. D. Browder, Oklahoma Gas & Electric Co.;

The Asheville Convention, by C. T. Almquist, University of Oklahoma, and delegate of the Section to the summer convention;

The Kansas City District Meeting, by F. J. Meyer, Oklahoma Gas & Elec. Co. Dinner preceded the meeting. September 21. Attendance 70.

Pittsburgh

Inspection trip through the plants of the Pennsylvania Rubber Co. and the Paramount Rubber Co. Joint meeting with the Engineers' Society of Western Pennsylvania. September 15. Attendance 195.

Portland

Recollections, by O. B. Coldwell, General Electric Co. Dinner meeting. September 22. Attendance 55.

St. Louis

Social meeting. September 23. Attendance 205.

San Antonio

F. A. Dale, Emory Peck & Rockwood, spoke about the Hamilton Dam under construction on the upper Colorado river. Illustrated with slides. September 22. Attendance 42.

San Francisco

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. Doctor Skinner showed several films taken on his recent trip around the world. Meeting was preceded by a dinner. September 11. Attendance 82.

Some Thoughts on Waves, by O. B. Blackwell, American Tel. & Tel. Co. Illustrated with slides. Dinner meeting. October 2. Attendance 156.

Sharon

Lightning Surges on Transmission Lines, by J. J. Torok, Westinghouse Electric & Mfg. Co. October 6. Attendance 112.

Spokane

Report of Summer Convention and Brief Description of Papers Presented at Asheville, by L. A. Traub, Home Tel. & Tel. Co., and delegate of the Section. September 25. Attendance 7.

Toledo

Results of Seven Years Radio Interference Investigation, by Fred C. Helwig, Toledo Edison Co.;

Symmetrical Components, Theory, and Application, by B. C. Harker, Westinghouse Elec. & Mfg. Co. September 25. Attendance 55.

Toronto

Economics, A Challenge to the Engineer, by Roy V. Wright, president A.S.M.E. Short talks by S. G. Porter, president, Engineering Institute of Canada, and L. B. Chubbuck, Canadian Westinghouse Co., Ltd., vice-president, Canada District No. 10, A.I.E.E. Joint meeting with the A.S.M.E. and Engineering Institute of Canada. October 2. Attendance 125.

Utah

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. Doctor Skinner showed and explained some pictures of the Orient taken on the occasion of his visit to that part of the world when he was a delegate to the World Engineering Congress. September 15. Attendance 75.

Vancouver

Inspection trip to the new fire alarm headquarters. C. C. Mulligan gave a description of the central fire alarm system and conducted the party through the various rooms of the building. September 12. Attendance 30.

Past Branch Meetings

University of Arkansas

Study of Electrical Grounds, by Ned Muse, student. October 6. Attendance 33.

University of California

Prof. G. E. Beggs, Princeton University, gave a talk on the design of suspension bridges and other structures.

Illustrated. Joint meeting with the A.S.C.E. and A.S.M.E., to which the public was invited. September 3. Attendance 450.

Initiation banquet. MOKELUMNE RIVER AND SALT SPRINGS PROJECT, by O. W. Peterson, Pacific Gas & Electric Co.;

JOSEPH HENRY, by Kenneth Hines, student. September 11. Attendance 41.

V. T. Johnson, chairman, gave a synopsis of his trip to the Pacific Coast convention held at Lake Tahoe in August. Prof. B. L. Robertson outlined his experiences with the General Electric Co. and at Pennsylvania State College. Prof. T. C. McFarland gave a talk on his trip to the east and his experiences at the Bell Telephone Laboratories, Inc., in New York. September 23. Attendance 57.

Clemson Agricultural College

LIGHTING DISTURBANCES, by A. S. Teague, student;

A TALK ON TELEPHONES, by W. M. Thames, student;

INDUSTRIES NEW RESPONSIBILITIES, by L. C. Black, student;

CURRENT EVENTS, by J. M. Turner, student. Short talks by Prof. S. R. Rhodes, counselor, and G. C. Jones, student. October 1. Attendance 46.

University of Denver

ADVANTAGES OF STUDENT MEMBERSHIP, by Prof. R. E. Nyswander, counselor;

FIELDS OF THE A.I.E.E., by L. C. Trussler, Branch chairman. September 21. Attendance 18.

Film "Big Deeds." September 29. Attendance 31.

University of Kansas

Mr. Evanson, General Electric Co., gave a demonstrated lecture on carrier currents superimposed on power lines. Illustrated. October 1. Attendance 85.

University of Kentucky

Election of officers as follows: W. A. Hunter, chairman; H. F. Day, secretary-treasurer. September 16.

HISTORY, AIMS, AND PURPOSES OF A.I.E.E., by Prof. W. E. Freeman, counselor, and vice-president, Southern District No. 4, A.I.E.E. September 30.

University of Louisville

ELECTRIC WELDING, by W. Stafford, student;

OIL FILLED CABLES, by C. Best, student. July 17. Attendance 11.

Missouri School of Mines & Metallurgy

Election of officers as follows: W. O. Woods, chairman; Wm. Pickles, vice-chairman; H. W. Short, secretary-treasurer. Three films shown as follows: "Pictures by Wire," "Voices Across the Sea," and "That Big Little Fellow." September 30. Attendance 18.

University of Missouri

Prof. M. P. Weinbach, counselor, spoke in detail concerning the purpose and organization of the A.I.E.E. Election of officers as follows: James E. Shepherd, chairman; Alfred L. Coffman, vice-chairman; Leslie E. Bates, Jr., secretary-treasurer. September 30. Attendance 50.

University of Nebraska

General discussion of programs for future meetings. September 30. Attendance 9.

Newark College of Engineering

MAGNETIC TESTING, by Mr. Shedd, student. Election of officers as follows: Edward Olsta, president; John G. Woehling, vice-president, Albert E. Day, secretary; George Barker, treasurer. September 21. Attendance 29.

University of North Carolina

Talks on the advantages of student enrolment in the A.I.E.E. by Profs. J. E. Lear, Bennett, and E. W. Winkler. October 1. Attendance 40.

Pennsylvania State College

Annual smoker. October 7. Attendance 90.

Pratt Institute

W. H. Sutton, chairman, gave a brief account of last year's activities and explained the purposes of the Student Branch and the advantages of membership in the A.I.E.E. September 24. Attendance 32.

Inspection trip to the Hudson Avenue plant of the Brooklyn Edison Co. October 5. Attendance 43.

Rice Institute

AIMS AND ACTIVITIES OF THE A.I.E.E., by Prof. J. S. Waters, counselor. September 30. Attendance 22.

University of South Carolina

Prof. T. F. Ball, counselor, gave a résumé of the activities at the Summer Convention held in Asheville, last June. October 2. Attendance 35.

Southern Methodist University

The advantages of student enrolment in the A.I.E.E. were presented by Prof. H. F. Huffman, counselor. Election of officers as follows: J. V. Melton, chairman; R. W. Smith, vice-chairman; R. L. Allen, secretary-treasurer. September 9. Attendance 34.

General discussion of plans for future meetings. October 7. Attendance 15.

University of Vermont

LIFE AND WORK OF FARADAY, by Donald E. Child, chairman. September 28. Attendance 20.

Virginia Military Institute

THE LIFE OF FARADAY, by S. N. Garret, student;

PHOTOGRAPHIC AERIAL SURVEYING, by W. R. Fuller, student;

ELECTRIC WELDING, by L. DeCamps, student;

LIFE OF GEORGE WESTINGHOUSE, by S. R. Chisman, student. Prof. S. W. Anderson, counselor, explained the organization and purpose of the A.I.E.E. and welcomed the new students. September 26. Attendance 76.

Virginia Polytechnic Institute

Discussion of Branch activities for the coming year. September 24. Attendance 21.

EXPANSIONS AND IMPROVEMENTS BEING MADE IN ELECTRICAL POWER PLANTS, by R. C. Hoffman, student;

COMMUNICATION, by M. W. Bowery, student. P. H. Cross elected secretary. October 1. Attendance 45.

West Virginia University

Election of officers as follows: A. W. Friend, president; D. C. Kennedy, vice-president; Philip Skaff, secretary, H. V. Locker, treasurer. September 21. Attendance 30.

The following talks were given by students:

FORD CHANGES FROM D-C. TO A-C., by L. Palmer;

RAILWAY ELECTRIFICATION, by D. C. Kennedy;

ELECTRIC LIGHTING BEFORE EDISON, by R. H. Colborn;

PRESSURE INDICATOR ON A DIESEL ENGINE, by J. Kayauha;

PENTODE VACUUM TUBES, by A. W. Friend. Prof. A. H. Forman, counselor, gave a short talk on the benefits of student enrolment in the Institute. September 28. Attendance 30.

The following talks were given by students:

PROGRESS IN ENGINEERING, by L. P. Kerwin;

POWER EXPLOITATION IN SWITZERLAND, by W. McMillian;

COPPER, by R. W. Blair;

POWER TRANSMISSION IN SOUTH AFRICA, by L. Post;

INJURIES PRODUCED BY SURGE DISCHARGES, by J. L. Simpson;

X-RAYS, by J. E. Wallace;

VACUUM TUBES, by F. Q. Brown;

SHORT RADIO WAVES, by N. I. Hall. October 5. Attendance 30.

Employment Notes

Of the Engineering Societies Employment Service

Position Available

SALES ENGINEER. An electric cable manufacturer wants a man to manage one of its branch sales offices. He must have a thorough electrical engineering education, either university or practical training. He must have had sales experience in the industrial field. He must have had sufficient executive experience to handle and direct men. If you do not have all three requisites please do not apply. If you have here is a real opportunity. W-2758 C.

Men Available

ELECTRICAL ENGINEERING GRADUATE, age 22, B. S. in E. E. from well-known engineering college. Ten months' experience on construction. Desires employment with utility, engineering, or manufacturing concern. References furnished. Available upon short notice. C-9885.

ELECTRICAL ENGINEER, 33, married, B. S. in E. E. Ten years' experience as engineer with utility company. Familiar with design of lines and stations; accounting set-ups; executive duties and powers; modern business practise; now studying corporation law. Available at once. C-4734.

1931 GRADUATE of five-year cooperative school in electrical engineering. E. E. degree, age 28, single. Cooperative experience includes machine shop practise, telephone central office trouble shooting, and experience with large municipal fire alarm system. Desires position with manufacturing concern or public utility. Willing to start at bottom. Location, Middle West preferred, but elsewhere satisfactory. C-9825.

ELECTRICAL ENGINEER, graduate Lehigh University '22. Experienced in all kinds of construction, transmission work, power plants, substations, etc., chiefly as draftsman laying out such work. Familiar with electrification in anthracite fields. Willing to accept drafting, engineering or any other electrical position. Eastern States preferred but anywhere considered. C-9723.

ELECTRICAL ENGINEER, technical school graduate. Thoroughly familiar with the layout and design of power and substations having held position of engineering supervisor with large public utility for the past ten years. Experienced in organization and maintenance of meter test department. Speaks Portuguese; seven years' foreign experience. Available at once. C-9886.

1931 ELECTRICAL ENGINEERING GRADUATE of midwestern university. Age 22, single. Experience limited but includes technical work acquired from summer employment with street railway and ceramic industry. Courses taken include vacuum tube control devices and radio. Desires position with manufacturing or engineering concern. C-9879.

ASSOCIATE ELECTRICAL ENGINEER, 37, married. Twelve years with Westinghouse; apprentice course, sales and shop. One and one-half years western electrical engineering department, writing inspection methods instructions. Knowledge of oscillograph testing and meters. C-8817.

ELECTRICAL ENGINEER, 21, single, B. S. degree in E. E., A & M College of Texas, 1931, holder of government broadcast class operator's license. Two years' experience in radio work. Desires position in radio or telephon industries. Available at once. Will go anywhere. C-9588.

GRADUATE ELECTRICAL ENGINEER, 22, single, B. S. degree in E. E., University of North Carolina, 1931. Four years' experience in radio work. Desires position in radio or vacuum-tube industries; excellent references; location immaterial; available upon two weeks' notice. C-9896.

1924 GRADUATE ELECTRICAL ENGINEER available at once. Six years' research and practical experience on insulation and cables of all kinds. Two years' work on inductive coordination. Best of references. C-2282.

1931 GRADUATE ELECTRICAL ENGINEER, B. S. degree, single, age 22, American. Desires position in the electrical industry with an opportunity for advancement. Location, immaterial. Available immediately. C-9909.

1930 ELECTRICAL ENGINEER, Drexel Institute, 24, single, in very good health, 1½ years' experience in making complete electrical tests on distribution, power and rectifier transformers, and metering equipment. Also G. E. Test floor experience. Desires position with public utility, or industrial concern. Available at once. Location, immaterial. C-9913.

CONSULTING ENGINEER, New York City, having good connections with companies building high voltage switching stations, seeks to represent in the East first class concern manufacturing equipment for same. C-9332.

TECHNICAL GRADUATE in electrical engineering, 29, single, 1½ years G. E. Test; over ten years' experience with leading electrical company in repair, testing of electrical apparatus. Desires position in testing and experimental work on motors, generators, etc. Future prospects considered more important than initial salary. Best of references. Available short notice. C-8778.

RECENT GRADUATE wants to use scientific and engineering knowledge as background for commercial and management activities. Desires connection with leading concern, salary secondary. Foreign languages, long residence abroad, good references. C-9920.

GRADUATE ELECTRICAL ENGINEER, 1925, 28, single, year and a half G. E. Test, two years electrical construction in plants and substations for large utilities, one year superintendent electrical construction in steam plant and substations in Brazil. Desires position with utility on construction or operation work. Location, immaterial. C-4770.

PLANT MANAGER OR CONSTRUCTION SUPERINTENDENT. Graduate electrical engineer, 39 years of age, with some experience in heavy chemicals. Fifteen years of varied experience in utility operation, factory management, production engineering, radio and construction. Available at once. Location, immaterial. B-7340.

ELECTRICAL ENGINEER, B. S. E. E. degree from southern university, 1931, age 21, single. Desires position with manufacturing concern offering a future, or as instructor in electrical engineering. Location, immaterial. Available at once. C-9607.

ELECTRICAL ENGINEER, 28, single. Graduate Georgia Tech '29, B. S. in electrical and civil engineering. Westinghouse Test floor, engineering school and design school. One year's experience in turbine generator design including development work. Desires position with future. Location, immaterial. Available immediately. C-9923.

ELECTRICAL ENGINEER, B. S. in E. E., Case '29, age 25, single. Two years' varied experience with General Electric Company. Desirous of position with opportunities. Available immediately. C-9918.

1931 ELECTRICAL ENGINEERING GRADUATE, age 22, single, B. S. in E. E. at Carnegie Tech. Tau Beta Pi. Experienced in drafting and power substation construction. Desires position in railroad electrification or operation, or with other power engineering firm. Location, immaterial, Available immediately. C-9925.

GRADUATE ELECTRICAL ENGINEER, 1929, Ohio State University. Age 26, married. Tau Beta Pi. One year Westinghouse student course. Sixteen months motor engineering, mostly synchronous motor design. Motor and control test experience. Good references. Available immediately. C-9924.

ELECTRICAL ENGINEER, Pratt graduate 1931. Some experience with resistor units, also with vacuum and photocell tubes. Has had office work in graphs, data, reports. Interested in airport lighting, television, and sound. Eastern location preferred. C-5636.

PATENT ATTORNEY, graduate engineer, connected with a well-known firm specializing in foreign applications. Desires to make a new connection. Familiar with design and development of small electrical and mechanical parts. C-846.

ELECTRICAL ENGINEER, 22, single, University graduate '31. Desires junior position in test or design departments of power machinery manufacturing concern. Experience limited. Location preferred, Eastern. Available upon short notice. C-9447.

ELECTRICAL ENGINEER, 40, married, graduate Federal Technical University, Zurich, Switzerland. Experienced in design, construction, operation of power stations, substations, transmission lines, purchasing electrical equipment, duct lines and cable work, railroad electrification, catenary design, extensive knowledge, pleasing personality. Available now, location, immaterial. C-683.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility, and industrial surveys covering: cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense, and cost analysis. Capable organizer. Profitable assistant to busy executive. Prefers East. Consider any proposition. B-9122.

ELECTRICAL ENGINEER, graduate recognized southern university, 34, married, G. E. Test; broad experience utility field, particularly underground systems, including

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
L. E. Griffith, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

design, maintenance of low voltage a-c. networks. Desires position with utility with responsibility for design or maintenance of underground, overhead system, or manufacturer working on design problems. Location preferred, Middle West or Southwest. C-1191.

PHYSICIST, middle-aged, experience in industrial research, supervision of research, executive work and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent American universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available upon short notice. C-7900.

ELECTRICAL ENGINEER, 33, married, graduate of Worcester Polytechnic Institute, 1921, B. S. in E. E. Two years' experience in railway work, eight years in engineering, design, purchase of equipment, and construction of power stations, switching stations and substations. Desires sales engineering work. Location, New York Metropolitan preferred. Available immediately. C-9928.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E. 1928, M. S. in E. E. 1929. Completed Westinghouse Graduate Student and Electrical Design school courses. One year's experience induction motor designer; six months laboratory instructor. Desires position as instructor on university staff or engineer with manufacturing concern. Location, United States. C-9936.

ELECTRICAL ENGINEER, M. S. 1931 from M. I. T. G. E. Test including railway American, age 22, married. Desires connection with electrical company or public utility or as instructor in electrical engineering, physics, or mathematics. Location, immaterial. C-9942.

GRADUATE ELECTRICAL ENGINEER, 28, single, B. S. in E. E. from University of Minnesota, eighteen months General Electric Test, twenty-three months telephone and telegraph engineering. Desires position with manufacturing or public utility company. Location and remuneration considered secondary to opportunity offered for future. Available at once. C-9285.

ELECTRICAL ENGINEER, 22, B. S. E. E., 1930. Desires connection with public utility, electrical or radio manufacturing company. G. E. Test experience. Six months work with vacuum tubes. Experience with large motors. Location, immaterial. C-9806.

EXECUTIVE, Industrial physicist, technical graduate with diversified research experience and excellent engineering training, desires position with American organization. Will also consider opening as assistant to able engineer or business executive. B-8987.

COMMUNICATIONS ENGINEER Twenty years' telephone, telegraph, and radio inside and outside construction and maintenance experience, mostly abroad. Considerable knowledg modern high speed telegraph systems, relays and circuits. Wire experience on wiring diagrams. Switchboards, etc. Could economically modernize communication systems preferably abroad. C-8805.

ELECTRICAL ENGINEER, 23, degree B. S. in E. E. University of New Hampshire '30. Fourteen months G. E. Test and general course. Test xperience in transportation, motors, and generators and vacuum tubes. Nine months' summer work in main line electric railway shops. Interested in any engineering work. Available n short notice. C-9859.

GRADUATE ELECTRICAL ENGINEER, ag 28, married. Four years' experience in power plant and substation design. Eighteen months in signal department of a rapid transit railroad. Western Electric training course for switchboard engineer. Can refer freely to past connections. Location immaterial. Available now. C-9944.

GRADUATE ELECTRICAL ENGINEER, 42, married. Sixteen years' experience in design of small and fractional horsepower motors including polyphase different types of single-phase now on market and d-c. motors. Considerable experience in manufacturing, testing and cost analyzing. C-9951.

COST REDUCTION ENGINEER, cooperative engineering graduate, 1927, B. S. in E. E., desires position with manufacturer of electrical or mechanical products. One requiring experience in plant layout, improvements, material handling, machine shop practises, chart and statistical analysis. Would also consider technical report work with an industrial appraiser. C-9916.

ELECTRICAL ENGINEER, 45, university graduate, experienced in th various branches of electrical engineering work of power companies, including work for industrial customers, desires position with power company or manufacturer. Permanent position desired, but will consider temporary work. B-1928.

ELECTRICAL ENGINEER, age 39, married, technical graduate, B. S. E. E. 1913. Eighteen years' experience in the public utility field. For the past eight years chief draftsman in charg of large department doing substation and power house design. Seeks new connection as company is dissolving. Available immediately. C-9953.

ELECTRICAL ENGINEER, 33, with eight years' experience in erecting and installing electrical machinery and control apparatus. Also previous factory testing. C-9954.

ELECTRICAL ENGINEER, 21, single, 1931 graduate with B. S. in E. E. Member of honorary fraternity in college and won scholarship three consecutive years. Summer experience with public utility. Interested in any electrical engineering field including vacuum-tube work. Available at once. Location, New York preferred, but not essential. C-9467.

RADIO ENGINEER, age 31, married, B. S. in E. E. from one of the greatest Western universities. Has broad theoretical and practical experience in radio engineering. Available at once. New York City preferred. C-6734.

PUBLIC UTILITY ENGINEER, technical college graduate, age 37. Twelve years' diversified experience in all branches of the utility business. Valuation work, rate investigation, cost analysis, statistical and financial research, engineering and sales work. Services offered to any company requiring a trained public utility man. B-9782.

1931 ELECTRICAL ENGINEERING GRADUATE, age 22, B. S. E. E. in well-known engineering college. Desires connection with manufacturing or public utility concern. Four months' experience with a large power company. Michigan or bordering states preferred. Available immediately. C-9940.

ELECTRICAL ENGINEER, 35, single, M. I. T., general business experience, hydro-electric station operator one year; taught E. E. in university 1½ years; preparation of instruction books for electrical and mechanical apparatus 3½ years. Desires position in research and development or as instructor. New York City preferred but not essential. Available immediately. C-2481.

GRADUATE ELECTRICAL ENGINEER, 25, single, B. S. in E. E., 1930 Mid West college. One year G. E. Test including work on railway motors, control equipment and locomotives. Railway or public utility work preferred. Location anywhere. Salary secondary to opportunity. References. Available immediately. C-9958.

GRADUATE ELECTRICAL ENGINEER, 23, of Rensselaer Polytechnic Institute, desires position in public relations department of power and light utility company. Two years of varied power and light experience. Location, immaterial. C-9957.

DESIGN ENGINEER, college graduate, 38, married. Nine years electrical substation and power house design, with switchboards, wiring diagrams, and all other important items. Five years testing engineer power station and research laboratories. Speaks Spanish, German, and Hungarian fluently. Available for immediate offer. Location, U.S.A. or any foreign country. C-9128.

ELECTRICAL ENGINEER, 1930 graduate; cooperative experience on machinery layout and power wiring; recently employed elevator appliance design, layouts, test, reorganization. Eastern Pennsylvania preferred. C-9963.

ELECTRICAL ENGINEER, 35, married with 15 years' experience. One year G. E. Test. Two years U. S. Navy. Twelve years with manufacturer of control specialties. Vast experience with elevators and elevator accessory equipment. Desires engagement with elevator manufacturer or one manufacturing a varied line of control apparatus. Locate anywhere. C-9956.

ELECTRICAL ENGINEER, 30, desires new location. Responsible, keen, with a good record covering 8 years' experience in the design, construction and operation of generation, transmission and distribution. Also successful experience in rating, public relations. Special studies made of rural distribution and service. C-9959.

SALES ENGINEER, 22, single with automobile. B. S. in E. E. Georgia Tech., 1929. Experience in all departments of a Southern utilities corporation. Eight months' sales experience. Available anytime, anywhere. C-9965.

INDUSTRIAL ELECTRICAL ENGINEERING GRADUATE, Pratt Institute 1931, 21, single. Specialized in high frequency circuits. Three years' experience in the radio field. Desires work with radio or sound concern. Available immediately. Location, East. C-9904.

JUNIOR ENGINEER, 1931 graduate, B. S. E. E. University of Alabama. Desires position with utility, construction, manufacturing company. Location immaterial. Experienced in power plant and building installation and industrial control, having been employed for eight summer months and one full year first as electrician's helper and then as first class electrician. C-9446.

SALES EXECUTIVE: with electrical training. Seven years' experience in sales engineering and sales through distributors. Well acquainted with sales conditions in various parts of country. Willing to tackle difficult job. C-5431.

ELECTRICAL ENGINEER, 1931 graduate State University, B. S. degree E. E. and M. S. degree I. E. Single, 24. Experienced electrician on construction work with limited experience as estimator in same field. Desires connection with engineering, manufacturing, or large contracting concern. Any location acceptable; South America preferred. Available upon short notice. C-9970.

ELECTRICAL ENGINEER, graduate, married, 28, with wide experience in industrial plant electrical construction and maintenance; railway electrification; power plant design, estimating, and supervisory construction experience with electric contractor; cost analysis. Desires position with future. C-4428.

DISTRICT SALES MANAGER OR MANUFACTURER'S AGENT, experienced engineering representative, desires connection with high-grade company that has line of industrial or utility equipment. Eastern location preferred. B-4067.

ELECTRICAL, MECHANICAL ENGINEER, college graduate with wide practical experience in power plant work and industrial electrical equipment. Desires connection, available immediately. B-2492.

Membership

Recommended for Transfer

The Board of Examiners, at its meeting of September 28, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Member

BURNETT, JAMES HENRY, asst. engr., Brooklyn Edison Co., Brooklyn, N. Y.

CORY, SAMUEL I., telephone engr., American Tel. & Tel. Co., New York

CURRIE, FRANK L., engg. asst., Western Union Telegraph Co., New York.

FITZGERALD, EDWARD B., elec. engr., The J. G. Brill Co., Philadelphia, Pa.

FOUST, CLIFFORD McCLAIN, elec. engr., General Elec. Co., Schenectady, N. Y.

GIERING, PERCIVAL L., consulting, elec. engr., City of Boston, Transit Dept., Boston, Mass.

GILMAN, WILLIAM F., executive adviser to management, Kwang Tung Electric Supply Co., Canton, China; residence, Belgrade Lakes, Main .

HANNAFORD, EARLE S., supervisor of education and training, American Tel. & Tel. Co., Atlanta, Ga.

JACOBY, S. CLIFFORD, supt., transmission and distribution, Montaup Electric Co., Fall River, Mass.

LONGFIELD, CLAUDE M., electrolysis engr., State Electricity Commission of Victoria, Victoria, Australia.

McCLENAHEN, R. A., engg. asst., United Engineers & Constructors, Inc., Newark, N. J.

OSBORNE, R. W., president, Osborne Electric Co., Toronto and Niagara Falls, N. Y.

PARRACK, VASCO R., engr., Tennessee Public Service Co., Knoxville, Tenn.

SCHLENKER, VESPER A., consulting acoustical engr., New York.

SMITH, JR., S. ARCHIBALD, asst. engr., transmission, Public Service Electric & Gas Co., Newark, N. J.

WEIL, JOSEPH, instructor, consulting engr., University of Florida, Gainesville, Fla.

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before November 30, 1931.

Arthur, A. L., Syska & Hennessy, New York, N. Y.
Baxter, F. I., Kansas City Public Service Co., Kansas City, Mo.
Beck, Wm. O., Kelly Island Lime & Transport Co., Clay Center, Ohio
Bennett, W., Loew's Columbia, Warner Bros., Tivoli, Universal Pictures Corp., Rialto Theatres, Washington, D. C.
Brown, T. A. (Member) Madison Gas & Electric Co., Madison, Wis.
Brucker, R. K. (Member) J. G. Wray & Co., Chicago, Ill.
Cartmell, R. H., 2008 E. Live Oak, Temple City, Calif.
Collins, I. W., Pacific Gas & Electric Co., Oakland, Calif.
Crossley, H. R., Dominion of Canada, St. John, N. B., Can.
Dahlem, J. G., Richard Kaupert, Milwaukee, Wis.
Danko, J. T., University of Pittsburgh, McKeesport, Pa.
Den Braven, G., L. Bamberger & Co., Newark, N. J.
Dilts, C. B., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Dunklin, G. T. (Member) Westinghouse Elec. & Mfg. Co., New York, N. Y.
Edwards, L. C., Pacific Gas & Electric Co., Emeryville, Calif.
Fox, L. H., Mississippi A. & M. College, A. & M. College, Miss.
Goodhue, Wm. M., Harvard University, Cambridge, Mass.
Griffith, L. A., Emerson Elec. Mfg. Co., Richmond Heights, Mo.
Hartman, E. R. (Member) Telephone Bond & Share Co., Kansas City, Mo.
Henderson, R. M., National Light & Power Co., Moose Jaw, Sask., Can.
Hottle, W. M., Western Electric Co., Kearny, N. J.
Howe, P. B., Philadelphia Electric Co., Philadelphia, Pa.
King, F. H., Holyoke Gas & Electric Dept., Holyoke, Mass.
Kitchen, W. A., Oklahoma Gas & Electric Co., Oklahoma City, Oklahoma
Klitten, A. H., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Lloyd, T. C., Antioch College, Yellow Springs, Ohio
Loewe, R., University of Wisconsin, Madison, Wis.
Lundelius, O. E., City of Austin, Austin, Tex.
Miller, J. F., Louisville Gas & Elec. Co., Louisville, Ky.
Milligan, L. S., Long Island State Park Commission, Babylon, L. I., N. Y.
Omar, S., General Electric Co., Schenectady, N. Y.
Poppe, F. W., 1282 Shakespeare Ave., New York, N. Y.
Porter, H. F. (Member) Allegheny Steel Co., Brackenridge, Pa.
Randel, E. S., Southwestern Bell Telephone Co., Kansas City, Mo.
Rowley, R. A., 23 Girard Ave., Hartford, Conn.
Sargent, F. J., Madison Gas & Electric Co., Madison, Wisconsin
Sewell, F. N., Texas Power & Light Co., Dallas, Texas
Sklar, H. L., Micamold Radio Corp., Brooklyn, N. Y.
Urbany, J. E., Coyne Electrical School, Chicago, Ill.
Vidmar, P. J., Illinois Testing Laboratory, Chicago, Ill.
Walch, D. E. (Member) General Electric Co., Boston, Mass.
Watts, J. H., Westinghouse Elec. & Mfg. Co., San Antonio, Tex.
Whitmore, R. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
43 Domestic

Foreign

Castells, C. L., Ericsson Sudamericana, Buenos Aires, Argentina, So. America
Dunlop, R. P., Hong Kong Electric Co., Ltd., Hong Kong, China
MacAlpine, R. W., British Thomson-Houston Co., Ltd., Rugby, Eng.
Repetto, E. L., Rivadavia 3079, Dto. G, Buenos Aires, Argentina, So. Amer.
Sakakibara, K., Hitachi Electrical Engineering Works, Hitachi, Ibaraki-ken, Japan
Satyanarayana, P., L. M. & S. Railway, Stonebridge Park, London, England
6 Foreign

November 1931

Order Form for Pamphlet Copies of A.I.E.E. Papers*

All papers presented at the South West District (No. 7) Kansas City Meeting

Number	Author	Title
☐ 31-132	J. Slepian and L. R. Ludwig	Backfires in Mercury Arc Rectifiers
☐ 31-133	H. W. Collins, E. E. Piepho and J. J. Torok	Impulse Voltage Tests on a 4,800-Volt Distribution Substation
☐ 31-134	C. W. Nystrom	Tape-Armored Telephone Toll Cable
☐ 31-135	O. B. Blackwell	The Time Factor in Telephone Transmission
☐ 31-136	E. K. Shively and G. S. Whitlow	Automatic Control for Variable-Ratio Frequency Converters
☐ 31-137	L. V. Nelson and E. L. Hough	Interconnection of the 25- and 60-Cycle System of the Union Electric Light and Power Company
☐ 31-138	J. N. Holsen	Forecasting Population for Engineering Purposes
☐ 31-139	W. D. Weidlein	Corona Energy Loss
☐ 31-140	E. J. Burnham	Overvoltage on Transmission Systems Caused by Dropping Load
☐ 31-141	J. Slepian and C. L. Denault	The Expulsion Fuse
☐ 31M8	P. N. Vinther	Electric Arc Welding in Building Construction
☐ 31M9	C. T. Almquist	Calculating Load Division in Distribution Systems
☐ 31M10	F. E. Sanford	Application of Primary Distribution Fuses
☐ 31M11	E. G. Newton	Fuse Cut-Outs—Their Design and Application for A-C. Distribution Circuits
☐ 31M14	C. C. McFarland	Advance Planning of Long Distance Telephone Facilities
☐ 31M15	P. H. Robinson	Effect of Wave Form on Operation of Induction Type Protective Relays

Papers presented prior to September 1931 and upon which articles in this issue are based

Number	Author	Title
☐ 31-64	J. R. Clem	Reactance of Transmission Lines with Ground Return
☐ 31-67	R. L. Davis	Power Equipment at New KDKA Station
☐ 31-94	G. Stamper and F. F. Ambuhl	Operating Experience with Automatic Stations
☐ 31-97	G. B. Shanklin and F. H. Buller	Characteristics of Oil Filled Cable
☐ 31-100	R. W. Atkinson and D. M. Simmons	Oil Filled Cable and Accessories
☐ 31-102	J. R. Eaton, J. K. Peck, and J. M. Dunham	Experimental Studies of Arcing Faults on a 75-Kv. Transmission System
☐ 31-108	D. W. Roper	Economics of High Voltage Cable
☐ 31-109	R. M. Stanley	Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control

*Members, Enrolled Students, and subscribers are entitled to one pamphlet copy of any paper in this list if requested within one year from above date. Thereafter a charge of twenty-five cents per copy will obtain.

Name..

Address..

Please order papers by number. ***Address*** **Order Department A.I.E.E., 33 West 39th Street, New York, N. Y.**

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Balaguer, Manuel M., c/o International Tel. & Tel. Co., 67 Broad St., New York, N. Y.

Bugg, Vernon M., 172 Elm Ave., Rahway, N. J.

Chilofsky, Joseph, 958 N. 7th St., Philadelphia, Pa.

Clark, Bernard, 79 Jenness St., East Springfield, Mass.

Cordier, N. A., 126 Chatterton Pkwy., White Plains, N. Y.

Farnlof, Charles G. T., 1318 Laketon Road, Wilkinsburg, Pa.

Garrison, F. G., Internat'l Tel. & Tel. Corp., Buenos Aires, Arg., So. Amer.

Kamm, J. Lloyd, 1801 N. Lamar St., Dallas, Texas.

McLean, James S., 190 Old Army Road, Scarsdale, N. Y.

Melson, Sydney W., Yeatton Woolrich Road, Abbey Wood, London, S. E. 2, England.

Merrill, J. L., 517 S. Orange St., Media, Pa.

Mountain, C. E., Burma Elec. Supply Co., Mandalay, Burma, India.

McCulloch, G. B., McVie Caterers, Ltd., Sydney, N. S. W., Australia.

Parr, J. C., 245-71st Street, Brooklyn, N. Y.

Pierson, Walter D., 4710 Locust St., Philadelphia, Pa.

Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.

Prudham, W. M., 100 Biddle St., Wilkinsburg, Pa.

Schrock, John E., 3720 Main St., Lawrence Park, Erie, Pa.

Stempfle, Frederick, 8126 E. Vernor Highway, Detroit, Mich.

Tate, William, Apartado No. 41, Publa, Mexico.

Voronovsky, T. G., 1162 Waverly Place, Schenectady, N. Y.

ENGINEERING SOCIETIES LIBRARY

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during September are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

ESTIMATING BUILDING COSTS. By F. E. Barnes. 3rd ed. N. Y., McGraw-Hill Book Co., 1931. 656 pp., illus., diagrs., charts, tables, 7 x 5 in., cloth, $5.00.——A handbook for contractors and estimators which groups the information needed for determining the amount of labor needed for the various building operations, the current prices of labor and materials, and the cost of replacing buildings built between 1890 and 1926. The data are arranged for quick consultation, usually in tabular form. Labor hours and bills of materials are given. This edition has been thoroughly revised, and new chapters have been added on building insulation, storage silos and circular bins, concrete masonry and cement gun work. The author is Building Valuation Engineer of the New York Central Lines.

DIE CHEMIE DER KOHLE. By W. Fuchs. Berlin, J. Springer, 1931. 510 pp., diagrs., charts, tables, 10 x 6 in., cloth, 45 r. m. ——This monograph summarizes present-day views upon the chemistry of coal, lignite, and peat and is said to cover the literature down to March, 1931. Chapter one treats of the chemical composition of the coal-forming plants and of their decomposition. Chapters two to four treat of peat, lignite, and coal, discussing their petrographic, physical and chemical characteristics, their reaction to chemical and biological agents, behavior when heated, origins, etc. The final chapter gives methods of analysis and discusses their results.

BRONZE UND ROTGUSS, NACH DIN 1705. Berlin, VDI Verlag, 1931. 100 pp., illus., diagrs., charts, tables, 8 x 6 in., paper, 7 r. m. ——Contains the papers and discussions presented at a meeting of the Society of German Engineers devoted to the properties and use of the standard German bronzes and red brasses. The structure and properties of brass and bronze castings, and the standard compositions are discussed, and the experiences of various users are presented. Methods of testing are given. A bibliography for the years 1921 to 1930 is included.

PLASTICITY. Mechanics of the Plastic State of Matter. By A. Nadai with A. M. Wahl, asst. author. Germany. McGraw-Hill Co., 1931. 350 pp., 6 x 9 in., pamphlet. Price $5.00 ($4.00 to members of Founder societies). ——Translated from the German based on the original work of Doctor Nadai (formerly prof. of ap. mech., Univ. of Goettingen, but now with Westinghouse Research Lab.). The original work is amplified by the addition of new information, bringing together the observations of engineers, metallurgists, and physicists, regarding the plastic deformation of metals. It summarizes laws now available for a more exact prediction of stress distribution, and discusses the fundamentals of the theory of plastic flow, especially in metals. This is the first of a series of publications to be prepared by the Engineering Societies Monograph Committee.

PRINCIPLES OF ELECTRICITY. By L. Page and N. I. Adams, Jr. N. Y., D. Van Nostrand, Inc., 1931. 620 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.25.——Intended for undergraduates who have completed general courses in physics and the calculus, and for advanced students who wish a more comprehensive training in electromagnetism. The ordinary subject matter of electricity and magnetism is treated comprehensively, with unusual space devoted to the phenomena of high-frequency and electromagnetic waves. The book aims to fill the gap between elementary texts and advanced treatises that call for wide knowledge of higher mathematics.

INDUSTRIAL ORGANIZATION. By H. Rubey. Boston & N. Y., Ginn & Co., 1931. 308 pp., diagrs., charts, tables, maps, 9 x 6 in., cloth, $2.80.——A brief but comprehensive course covering such fundamentals of business as promotion, finance, management, organization, marketing, personnel, accounting, estimating, valuation, etc. The book is intended primarily to give the engineer some knowledge of business, in preparation for executive and managerial work; will be useful also to others who wish a general survey of this field.

ALTERNATING CURRENTS. By C. E. Magnusson. 4th edit. N. Y., McGraw-Hill Book Co., 1931. 685 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $5.00.——A text-book for undergraduate students which discusses the fundamental principles of the subject and shows their application to industrial problems. The changes in this edition include a rewriting and extension of the chapter on instruments, new chapters on systems of units and symbols, on mercury-arc rectifiers and on hot-cathode rectifiers and oscillators, as well as many new diagrams and illustrations.

ELECTRICAL EQUIPMENT. By H. W. Brown. 2nd edit., N. Y., McGraw-Hill Bk. Co., 1931. 586 pp., illus., diagrs., charts, tables, 9 x 6 in., $5.00.——This text-book is intended to teach students of engineering and others interested in the practical applications of electricity how to apply their knowledge of the theory of operation of electrical machines and the data given in handbooks to the equipping of shops, factories and industrial plants. The requisites of power plants and distribution systems, the characteristics of various motors, generators, transformers, regulating and protective devices, heating and welding apparatus, etc., are discussed and their suitability for various classes of work pointed out.

PROJECTING SOUND PICTURES. By A. Nadell. N. Y., McGraw-Hill Bk. Co., 1931. 265 pp., illus., diagrs., charts, 9 x 6 in., cloth, $2.50.——A book for theater men interested in the reproduction of sound. The principles underlying the mechanisms and circuits used for that purpose are described in a simple, practical manner, and attention is given throughout to the more common troubles of sound apparatus and methods of preventing them.

TECHNICAL WRITING. By T. A. Rickard. 3rd edit. N. Y., John Wiley & Sons, 1931. 337 pp., 8 x 5 in., cloth, $2.00.——Interest in correct speech has become much more widespread since Mr. Rickard's book first appeared in 1919, and many text-books have appeared since that date. His work still remains, however, one of the most readable and best guides to the engineer who wishes to improve his power of expression. It may be recommended heartily. This new edition, prepared for the American Institute of Mining and Metallurgical Engineers, differs from the second edition only in sundry small corrections.

Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Agricultural Machinery

ELECTRIC. Electricity and the Farmer, D. N. McHardy. *Elec. Rev.*, vol. 109, no. 2805, Aug. 28, 1931, pp. 319-320, 1 fig. Critical views by head of engineering department of Harper Adams Agricultural College on present position and future possibilities of application of electricity to agriculture; power for barn machinery and dairy; electricity for heating and cooking; part played by mobile tractor; possibilities of future.

Anemometers

An Anemometer for a Study of Wind Gusts, R. H. Sherlock and M. B. Stout. *Univ. Mich.—Eng. Research Bul.*, no. 20, May 1931, 38 pp., 25 figs. partly on supp. plate. New type of pressure-plate anemometer developed for use in general program of research on loading and strength of overhead lines; equipped with magnetic transmitter and uses oscillograph for recorder; can record accurately average wind velocity over intervals of time as small as 1/8 sec.

Busbars

Structural-Shape Conductors Show Increased Efficiencies, H. W. Papst and D. I. Bohn. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 418-419, 3 figs. In order to avoid shortcomings of tubes and bars new type of conductor consisting of structural shapes has been developed; new conductor is designed for currents of about 2,000 to 7,000 amperes at 60 cycles and combines various desirable properties of both tubes and bars; channel conductor ratings are given.

DESIGN. Le calcul des barres omnibus tubulaires aux points de vue mécanique et électrique (Electric Mechanical Strength Calculation of Tubular Busbars), R. Beyaert. *Electricien*, vol. 62, no. 1521, Aug. 1, 1931, pp. 348-353, 2 figs. Simple mathematical analysis with various numerical examples pertaining to aluminum and steel tubular busbars.

Cables

OIL-FILLED. The Theory of Oil-Filled Cable—II, G. B. Shanklin and F. H. Buller. *Gen. Elec. Rev.*, vol. 34, no. 9, Sept. 1931, pp. 523-530, 9 figs. Mathematical theory; loading, and steady-state temperature conditions; thermal transients; operational equations for transient temperatures; solution of operational equations; oil demand; systems of oil feed and reservoir characteristics.

RESERVOIRS. Oil-Pressure Reservoirs for Underground Cables, T. C. Aitchison. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 410-415, 20 figs. Oil-pressure reservoirs are considered essential to successful operation of oil-filled and solid cables above 25 kv.; principal functions; various equipment and accessories are illustrated and described.

TELEPHONE. Securing Freedom from Cable Trouble, R. R. Rex. *Telephony*, vol. 101, no. 10, Sept. 5, 1931, pp. 30-31. Some helpful suggestions for securing freedom from telephone man's imaginary cable trouble; importance of periodic inspection and accurate records; discussion of causes of cable failure; suggested methods for locating trouble.

TESTING. The Electrical High-Pressure Testing of Cables and the Localization of Faults, J. Urmstom. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 416, Aug. 1931, pp. 983-1003 and (discussion) 1004-1012, 35 figs. Electrical high-pressure testing of cables, immediately after installation is completed, is discussed; author concludes that high-pressure d-c. test is useful and fulfils ordinary requirements; new connection for high-pressure d-c. testing set is described; methods of localization of more difficult kinds of faults are given; these show that there are very few faults which cannot be fairly accurately located.

UNDERGROUND MANHOLES. High-Pressure Manhole Washing Saves Expense of Opening Drains, C. B. Sharp. *Elec. World*, vol. 98, no. 7, Aug. 15, 1931, pp. 283-284, 1 fig. Forty plugged manhole drains was average per month reported on underground system of Detroit Edison Co. when manholes were being cleaned by hand; number has been reduced to 28 through use of water at 120-lb. pressure supplied from tank truck; also cleaning is done better, quicker and with fewer men.

Case Hardening

CARBURIZING. A New Method of Case-Hardening in an Electric Furnace. *Mar. Engr. and Motorship Bldr.*, vol. 54, no. 648, Sept. 1931, p. 351, 1 fig. Equipment introduced into England by Wild-Barfield Electric Furnaces, Ltd.; description of process, with costs of operation.

Cavitation

HYDRAULIC TURBINES. Cavitation of Large Turbine Runners, A. S. Robertson. *Elec. News*, vol. 40, no. 16, Aug. 15, 1931, pp. 35-36 and 38, 3 figs. Average maintenance costs amount to about $450 per runner per year using electric arc welding.

Circuit Breakers

TESTING. Testing Breaker Insulation by Power-Factor Methods, F. C. Doble. *Elec. World*, vol. 98, no. 9, Aug. 29, 1931, pp. 374-375. Author is reviewing work done by his organization in testing about 14,000 bushings and analyzing circuit-breaker insulation conditions by power factor method as applied to 11-kv. to 150-kv. equipment, and stressing advantages of a-c. test as compared with d-c. procedure and discussion by C. L. Dawes and C. A. Adams of Harvard, C. A. Powel of Westinghouse Electric & Manufacturing Co. and other outstanding men of electric manufacturing and power supply industry.

Circuits

ELECTRIC. Mathematical Analysis of Non-linear Circuits—I, A. Boyajian. *Gen. Elec. Rev.*, vol. 34, no. 9, Sept. 1931, pp. 531-537, 7 figs. In recent years, both troublesome problems and useful applications of networks with non-linear branches have been rapidly increasing, calling for more thorough and comprehensive analysis of phenomena involved; although physical or graphical analysis may prove sufficient for purpose, yet whenever possible mathematical analysis is highly desirable; more important non-linear circuits are: saturating circuits, arc circuits, and thermionic circuits; purpose of study is to develop technique that is applicable to all such circuits.

Transients in Grounded Wires Lying on the Earth's Surface, J. Riordan. *Bell System Tech. Jl.*, vol. 10, no. 3, July 1931, pp. 420-431, 4 figs. Voltages during transient conditions in grounded wire lying on earth's surface due to current in second grounded wire also on earth's surface are formulated for types of transient currents ordinarily obtained in a-c. and d-c. circuits; fundamental formula is for voltage due to unit step current, that is, current zero for time less than zero, and unity for time greater than zero; curves are given for function determining this voltage for wide range of values of its two parameters.

Conductivity

METALS. The Problem of the Electrical Conductivity of Metals, C. D. Niven. *Can. Jl. Research*, vol. 5, no. 1, July 1931, pp. 79-86. It is pointed out that mathematicians in their attempts to form theories of electrical conduction, do not lay emphasis on fact that at low temperatures, resistance, as a rule, does not vanish; in those cases in which it does, it vanishes suddenly; in view of this, question arises as to whether right model for conductivity metal is visualized; it is suggested that fundamentally a metallic atom is one in which electron configuration is incomplete.

Cooling

TURBO-GENERATORS. Hydrogen-Cooled Generators Have Economic Merit, M. D. Ross. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 403-409, 3 figs. In design of large turbo-generators next major step will be adoption of hydrogen gas as cooling medium; hydrogen is desirable as it has somewhat better heat transfer properties than helium, lower density and is available commercially at relatively low cost; density of commercial hydrogen is about 8 per cent that of air, so that windage losses, which are relatively high in turbo-generators, are reduced to negligible figure.

Dielectrics

TESTING. Dielectric Phenomena at High Voltages, B. L. Goodlet, F. S. Edwards and F. R. Perry. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 414, June 1931, pp. 695-727 and (discussion) 727-735, 36 figs. Breakdown of air, oil and solid dielectrics by normal-frequency impulsive and high-frequency voltages; large amount of original numerical data is given, covering entire range of voltage up to 1 million volts.

Education

ENGINEERING. Technical Education, H. L. Guy. *Engineering*, vol. 132, no. 3422, Aug. 14, 1931, pp. 201-202. Editorial comment on address before Oxford Summer School; author presses earnestly for closer correlation between works and technical schools; he suggests that summer school provides, perhaps easiest plan of any for keeping technical colleges in touch with practical problems.

RESEARCH. The Function of Research in Engineering Education, D. C. Jackson. *Science*, vol. 74, no. 1912, Aug. 21, 1931, pp. 183-187. Research not only has function in engineering education, but is integral part of properly conceived engineering education; investigatory spirit and achievement are more important attributes for engineering teacher than higher degrees; spirit for establishing research laboratories and foundations in engineering schools is presage of good educational spirit in schools. Before Soc. Promotion Eng. Education.

Electric Drive

COAL PREPARATION PLANTS. Electrification Problems in Modern Preparation Plants—I and II, E. J. Gealy. *Coal Age*, vol. 36, nos. 7 and 9, July 1931, pp. 346-348 and Sept., pp. 477-478 and 482, 3 figs. July: Review of development in design and construction; importance of observing certain fundamental principles; standardization of equipment. Sept.: Choice of motors, motor starters, pushbutton control, safety switches, power factor, welding, and lighting.

PUMPS, CENTRIFUGAL. Some Notes on Electrically Driven Centrifugal Pumps, H. E. Beckwith. *Am. Water Works Assn.—Jl.*, vol. 23, no. 8, Aug. 1931, pp. 1120-1127. Characteristics of inadequate installations; rapid method of checking pump efficiency; table of gallons of water delivered per kw-hr. against various heads on assumption that pump and motor are 100 per cent efficient; results of checking efficiency; measuring output of water.

Electrolysis

The Preparation of Organic Compounds by Electrolytic Methods—IV, S. Glasstone. *Indus. Chemist*, vol. 7, no. 79, Aug. 1931, pp. 315-317. Chemical and electrochemical halogenation; electrochemical chlorination; manufacture of bromoform and iodoform; chloroform and chlorhydrin; electrochemical diazotization.

Engineers

SALARIES. Relation Between an Engineering Education and Income, J. D. Beatty. *Indus. and Eng. Chem.*, vol. 23, no. 9, Sept. 1931, pp. 1070-1074, 6 figs. How salaries of engineers compare with salaries of men in other professions; what groups in engineering profession receive best salaries; how salaries of engineering graduates of Carnegie Institute of Technology compare with salaries of graduates from other engineering institutions generally.

Frequency

STANDARDIZATION. Frequency Standardisation. *Engineer*, vol. 152, no. 3941, July 24, 1931, p. 96. When general interconnection was deemed to be desirable problem of frequency standardization presented itself, but it remains to be seen whether widespread interconnection will prove great boon; on frequency standardization alone very large amount of money is being spent.

Furnaces

ANNEALING. Applications of the Electric Furnace for Non-Ferrous Metals With Special Reference to the Bright Annealing Process, H. C. Kloninger, G. Keller and H. Meuche. *Inst. Metals—Advance Paper*, no. 575, for mtg. Sept. 14-15, 1931, 18 pp., 12 figs. Main types of furnaces used for bright-annealing process; during past few years considerable improvements have been made in quality of product as well as in simplifying handling of annealed metals.

ARC. Twenty Year Advance in Electric Arc Furnaces for the Production of Iron and Steel, W. E. Moore. *Electrochem. Soc.—Preprint*, no. 60-11, for mtg. Sept. 2-5, 1931, pp. 65-78. In period of two decades electric arc melting furnace has made wonderful progress, having increased in number 65 times, in maximum size per heat five times, in maximum daily capacity 10 times, and power consumption per unit ton output has been decreased from 600-800 to 400-600 kw-hr.; carbon electrode consumption decreased from 30-40 lb. (14-18 kg.) down to 8-15 lb. (3.6-6.8 kg.).

ELECTRODES. The Soderberg Electrode, Oblong Electrodes and Other New Developments, M. Sem. *Electrochem. Soc.—Preprint*, no. 60-20, for mtg. Sept. 2-5, 1931, pp. 199-210, 4 figs. Electric furnace engineers originally objected to round cross section Soderberg electrode; they were convinced that oblong or rectangular electrodes were essential for efficient furnace operation; oblong electrodes produce larger active hearth, and gases evolved during furnace operation are more evenly distributed through charge; however, round electrodes are often to be preferred on account of certain electrical features and advantages.

HEAT TREATING. Electricity Used on a Large Scale for Heat Treating, G. Coley. *Iron Age*, vol. 128, no. 12, Sept. 17, 1931, pp. 747-751, 8 figs. Description of heat-treating furnaces; pig iron from blast furnaces and cupolas is duplexed with electric furnaces for making iron castings, at plant of Ford Motor Co.

INDUCTION. Tonnage Melting by Coreless Induction—VI, E. F. Northrup. *Fuels and Furnaces*, vol. 9, no. 9, Sept. 1931, pp. 1067-1071, 1 fig. Various classifications under which coreless induction melting may be considered; use of coreless induction furnace as refining furnace and ladle; future of industrial melting.

INDUSTRIAL. Heat Treating, Forging and Melting with Electricity, G. Coley. *Iron Age*, vol. 128, no. 11, Sept. 10, 1931, pp. 678-683 and 721, 12 figs. Equipment and procedure at plant of Ford Motor Co. with connected load of 85,000 kw., electric furnaces for duplexing blast-furnace and cupola iron in foundry, and indirect arc furnaces in brass foundry.

Fuses

ELECTRIC. Fuse Performance in Relay Service, H. D. Braley. *Power*, vol. 74, no. 6, Aug. 11, 1931, pp. 200-201. Test results show how accurate fuses of same size are in time of interrupting overload, how sensitive they are to load changes, and how selective two or more fuses, of different sizes in series, are in clearing fault on power systems.

Gases

CONDUCTIVITY. The Conductivity of Gases in Uniform Electric Fields, S. P. McCallum. *Lond. Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 76, Aug. 1931, pp. 384-392. In many recent publications various theories of electrical discharge have been elaborated which are based on hypotheses of doubtful validity; attention is drawn to objections that have already been raised to these theories, and results are compared with results of experiments on monatomic gases which have recently been made at Electrical Laboratory, Oxford.

Generators

GROUNDING. The Effects on Noise Induction of Grounded Neutral Generators. *Nat. Elec. Light Assn.—Pub.*, no. 153, Aug. 1931, 4 pp. Results of investigations of effects on noise frequency induction of grounded neutral generators feeding directly on line; nature and source of difficulties experienced are explained and several possible remedial measures are described.

Grid Glow Tube

CONTROL. Application of the Grid-Glow Tube to Oil Burner Control, J. P. Kriechbaum, J. V. Breisky and T. Draper. *Oil Heat*, vol. 4, no. 9, Sept. 1931, pp. 11-12 and 66, 2 figs. Design, construction and operating features of Protecto Glow System; oil burner safety devices.

Harmonics

MEASUREMENTS. Measuring Voltage Harmonics, E. Heuter. *Elec. Rev.*, vol. 109, no. 2804, Aug. 21, 1931, pp. 280-281, 4 figs. Instrument described depends on simple application of resonance principle and enables magnitude of voltage harmonics to be measured directly.

Heating

GREENHOUSES. Electrically Heated Greenhouse, G. N. Hawley. *Elec. World*, vol. 98, no. 8, Aug. 22, 1931, pp. 322-323, 2 figs. Electric heating of greenhouse at Riverside, Calif., has proved so successful that another new and profitable field for industrial heating has been opened to power company and nurserymen are able to make 75 per cent saving in investment for heating equipment.

RAILROAD SHOPS. Railroad Saves Six Times Electric Heat Cost, W. S. Scott. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 423-427, 3 figs. Study was made of major heat-treating operations in repair shops of Norfolk & Western Railway, and figures arrived at, and agreed upon, as conservatively representing annual savings by virtue of electric heating; power cost $17,805 in one year and savings credited to its use in electric heat amount to more than $100,000.

Hydroelectric Plants

AUTOMATIC. The Upper Notch Automatic Hydro-Electric Power Plant, R. F. Legget, P. J. Croft, J. R. Desloover. *Eng. Jl.*, vol. 14, no. 8, Aug. 1931, pp. 437-444, 12 figs. Plant located on Montreal river, 15 mi. southeast of Cobalt, northern Ontario; equipment consists of two 48-ft. head, 6,500-hp. 125-r. p. m. turbines, and two 6,500-kva., 11,000-volt, 25-cycle generators; switchgear and control equipment are fully automatic and are designed for possible remote control from distant point; switchgear is of metal clad type; station output transformed to 110,000 volts by three 4,500-kva. transformers and is fed into extensive network by means of line 32.7 mi. long.

INTAKES. Recent Applications of Draft Distributors to Power Plant Intakes, H. G. Acres. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, pp. 403-410, 13 figs. Rational design of intakes long neglected; studies made for Queenston-Chippawa plant in Canada led to development of Johnson-Wahlman draft distributor; four intakes designed to meet diverse conditions; elements of ideal intake design; intake of Chelan development of Washington Water Power Co. of Spokane; 14 ft. and 17 ft. in diam.; intake for St. John River Power Co. at Grand Falls, New Brunswick; delivers 7,500 sec. ft.; design of intake for projected development of 10,000- to 12,000-sec. ft. capacity.

Illuminating Engineering

RUSSIA. Progress in Illuminating Engineering in the U. S. S. R., Slokhay-Natalchenko. *Illum. Engr.*, vol. 24, Sept. 1931, pp. 220-222, 4 figs. During period 1921-30 illuminating engineering has made great progress in U.S.S.R.; vital part played by illumination is now recognized fact; good lighting is regarded as important in all branches in industry, and especially as means of improving safety and health; there are quite a number of laboratories interested in illumination in Leningrad, Kharkov, Moscow and other cities; notes on Illumination Congress of U.S.S.R.

Industrial Plants

ELECTRIC CONTROL. Centralized Control for Aggregate Plant, L. F. Leurey. *Elec. West.*, vol. 67, no. 3, Sept. 1, 1931, pp. 120-123, 8 figs. Electric operation of modern sand and gravel plant of Kaiser Paving Co., Pleasonton, Calif.; raises operating efficiency through reducing starting time and labor costs.

ELECTRIC POWER. Distributing the Electric Energy, R. G. Hornberger. *Maintenance Eng.*, vol. 89, no. 8, Aug. 1931, pp. 381-384, 3 figs. Review of design fundamentals of distribution system in industrial plant; typical wiring layouts.

Industrial Electrification—I and II, R. H. Wilmot. *Elecn.*, vol. 107, nos. 2775 and 2777, Aug. 7, 1931, pp. 186-189 and Aug. 21, pp. 247-249, 6 figs. Numerous advantages of electrical drive; use of a-c. or d-c. supply; private power generation or public power supply; mechanical *vs.* electrical drive; comparison of costs is given in numerical examples.

Insulating Materials

PORCELAIN. Mechanical and Thermal Shock Tests on Cermic Insulating Materials, H. M. Kraner and R. A. Snyder. *Am. Ceramic Soc.—Jl.*, vol. 14, no. 9, Sept. 1931, pp. 617-623, 3 figs. Simple tests, as developed for daily production of electrical porcelain; laboratory tests and results for number of ceramic insulating materials; from these it is shown that mechanical strength and resistance to thermal shock are valuable indications of mechanical properties of bodies and glazes; results obtained in testing foreign and American-made porcelains are compared.

The Effect of Firing Temperature on the Dielectric Strength of Porcelain, A. J. Monack and L. R. Shardlow. *Am. Ceramic Soc.—Jl.*, vol. 14, no. 9, Sept. 1931, pp. 603-607, 5 figs. Electrical porcelain body was fired to various cone temperatures and puncture voltages were determined; data from tests in which number of specimens used was sufficiently large to give mean values with small probable errors.

Insulating Oil

Report of Insulating Oils. *Int. Electrotech. Commission—Report of mtg. Advisory Committee*, no. 10, Stockholm, June-July, 1930. Documents from Canada, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Switzerland, Sweden, and United States, in their respective languages.

Insulators

TESTING MACHINES. Testing Machine for Insulators. *Engineering*, vol. 132, no. 3420, July 31, 1931, pp. 130-132, 7 figs. Testing machine, installed in high-tension laboratory of General Electric Co., enables insulators to be subjected to longitudinal and transverse stresses while exposed to electric pressure; made by W. and T. Avery; it is suitable for testing insulators of either post or string types, and can be used for tension or torsion tests, or for combination of two, and also for combined tension and vibratory test, up to maximum load of 24,000 lb

Lamps

GLOW. Gaseous Discharge Tubes. *Elecn.*, vol. 107, no. 2778, Aug. 28, 1931, pp. 273-275, 8 figs. Ripple neon; possibilities of hot cathode lamp; neon tubes as plant stimulant; actual photographs of various forms of blue ripple discharge; photographs of neon ripple and striated discharge; hot cathode lamp circuit for single phase a-c. supplies; and for three-phase supplies; characteristic of hot cathode tube.

Light and Lighting

Brightness Contrasts Determine Visual Efficiency, M. Luckiesh. *Elec. World*, vol. 98, no. 7, Aug. 15, 1931, p. 280. Although it is impractical to present complete table of brightness contrasts encountered in seeing, number of typical examples which have wide application have been selected for purpose of illustration, are given.

STREET. The Evaluation of Glare in Street-Lighting Installations, W. S. Stiles. *Illum. Eng.*, vol. 24, Aug. 1931, pp. 187-189, 4 figs. Maximum permissible glare; glare curves of center suspension and staggered suspension systems; elimination of glare from distant lamps; methods of calculation elucidated in appendix. (Concluded.)

Lightning Protection

SIGNALS AND SIGNALING. Lightning on Signal Power Lines, O. L. Jones. *Ry. Signaling*, vol. 24, no. 8, Aug. 1931, pp. 276-279, 4 figs. Results of certain field and laboratory analyses of lightning disturbances on signal power transmission lines; wiring diagram of signal power circuit. Bibliography.

Loud Speakers

Means for Radiating Large Amounts of Low Frequency Sound, E. W. Kellogg. *Acoustical Soc. Am.—Jl.*, vol. 3, no. 1, pt. 1, July 1931, pp. 94-110, 3 figs. Principals and possibilities of electroacoustic device of large radiating power are discussed; consideration of possible types of loud speaker with large area single diaphragm with baffle; large area composed of multiple units, with baffle; multi unit, short horn construction; long horn type, one or several unit; siren type with horn.

Magnetic Alloys

PROPERTIES. Some Magnetic Alloys and their Properties, H. H. Potter. *Lond. Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 76, Aug. 1931, pp. 255-264, 4 figs. One of most striking physical properties of element manganese is its tendency to form in conjunction with other non-ferromagnetic elements binary and ternary alloys which show pronounced ferro-magnetism; complete analysis of magnetic properties of binary and ternary alloys conveying manganese is given.

Magnetic Hardening

METALS. Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. *Metallurgia*, vol. 4, no. 20, June 1931, pp. 47-50, 10 figs. Precession theory of hardening; graphs illustrating results of experimental work, leading to new conception of philosphy of hardening, including quench-hardening, work-hardening, age-hardening, and hardening of work-hardened metals by low-temperature annealing. Bibliography.

Measurements

Precision Measurements of Alternating Currents Up to 2,000 Amperes, A. H. M. Arnold. *Jl. Sci. Instruments*, vol. 8, no. 5, May 1931, pp. 154-155. Figures are given of performance of current transformer with nickel iron core, having ratio 2,000/1, operating on burden of 100 volt-amperes at rated current; ratio is within 3 parts in 10,000 of its nominal value in frequency range 25 cycles per sec. to 100 cycles per sec. at full current to one-tenth of full current; in conjunction with non-inductive resistance of accurately known value and electrostatic voltmeter, transformer may be used for measuring currents up to 2,000 amperes with accuracy of few parts in 10,000.

Measuring Instruments

SPECIFICATIONS. Report on Electrical Measurement Instruments. *Int. Electrotech. Commission—Report of mtg. Advisory Committee*, no. 13, Stockholm, June-July 1930. Documents from Argentina, Germany, Italy and United States in their respective languages.

Mica

ELECTRIC PROPERTIES. Some Electrical Properties of Foreign and Domestic Micas and the Effect of Elevated Temperatures on Micas, A. B. Lewis, E. L. Hall and F. R. Caldwell. *U. S. Bur. Standards—Jl. Research*, vol. 7, no. 2, Aug. 1931, pp. 403-418, 8 figs. Number of samples of mica, fairly representable of major sources of world's supply, were tested for dielectric constant, power factor, dielectric strength, and ability to withstand elevated temperatures; results.

Motors

ALTERNATING CURRENT. A-C. Commutator Motors. *Elec. Rev.*, vol. 109, no. 2805, Aug. 28, 1931, pp. 323-324, 7 figs. Widespread adoption of a-c. has resulted in paying of increased attention to variable-speed a-c. three-phase motors; shunt performance curves of motor with series characteristics are given.

ENCLOSED. Enclosed Electric Motors. *Engineer*, vol. 152, no. 3943, Aug. 7, 1931, p. 152, 4 figs. Motors designed by Lancashire-Dynamo Motor Co., Trafford Park, Manchester, to meet adverse conditions; one of them is totally enclosed machine primarily designed for gas works; other is totally enclosed frame-cooled machine, known as "Tefeo" motor; it is standard Lancashire squirrel-cage or slip-ring machine, fitted with internal end shields and special end covers.

FRACTIONAL HORSEPOWER. Voltage Relations and Losses in Small Universal Motors, A. F. Puchstein and I. S. Campbell. *Ohio State Univ. Studies—Eng. Experiment Station—Bul.*, no. 58, Jan. 1931, 27 pp., 24 figs. Importance of data on universal motors; general test results and conclusions; apparatus arrangement and test methods used; determination of losses; voltage-vector test data and results; motor-loss test data and results. Bibliography.

SPEED REGULATION. Speed Regulation of Alternating-Current Motors, G. W. Stubbings. *Mech. World*, vol. 90, no. 2330, Aug. 28, 1931, pp. 196-198, 2 figs. Three principal methods of speed control discussed are pole changing, rheostatic control of rotor resistance, and use of commutator.

SYNCHRONOUS. New Synchronous Motor for High-Torque Loads, R. S. Wright. *Elec. World*, vol. 98, no. 8, Aug. 22, 1931, pp. 320-322, 6 figs. Design engineers worked for several years to perfect motor having desirable running characteristics of standard synchronous motor yet capable of developing high starting and pull-in torque with low starting current; result of these investigations has been development of new low-speed (450 r. p. m. and below) motor which has mechanical simplicity and is highly efficient.

Networks

FAULT RECORDERS. Der Siemens-Stoerungschreiber (Siemens' System Disturbance Recorder), W. Hofmann and P. M. Pflier. *Siemens Zeit.*, vol. 11, no. 7, July 1931, pp. 325-333, 12 figs. Analytical review of various types and their characteristics; new three-phase automatic recorder of Siemens' and Schuckert, and its testing; test data are given in curves and tables.

PROTECTION. Relay Study for the Application of Impedance Relays to Ground Fault Protection, L. S. C. Tippett. *Instn. Engrs. Australia—Jl.*, vol. 3, no. 7, July 1931, pp. 233-243, 16 figs. Method of applying theory of symmetrical components to analysis of performance of impedance relays of conventional design when used for protection against ground faults; as preliminary to this method of determining correct impedance networks of any given system is discussed, under various operating conditions; application is made to portion of Victorian State Electricity Commission's system which gives ample illustration of principles involved.

Photoelectric Cells

Recent Contributions to Light Valve Technic, O. O. Ceccarini. *Soc. Motion Picture Engrs.—Jl.*, vol. 17, no. 3, Sept. 1931, pp. 305-320 and (discussion) 320-325, 15 figs. Structural changes made in light valves with object of improving their quality, stability of operation, and efficiency, most important being introduction of damping to off-set resonance; these features are chiefly considered from standpoint of production requirements and engineering economies; new synchronous slit type oscillograph permitting study of behavior of valve is described.

Ionization in Gas-filled Photoelectric Cells: The Inert Gases in Coesium on Silver Photoelectric Cells, and Time Lag in Gas-filled Photoelectric Cells, W. F. Tedham. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol.12, no. 76, Aug. 1931, pp. 224-232, 8 figs. Some uncertainty appears to exist as to best gas-filling in use in photoelectric cells which are sensitive to visible or infra-red light; in view of this uncertainty, question of relative advantages of helium, neon, and argon, and also krypton and xenon as gas-fillings in photoelectric cells were reinvestigated in some experiments.

Power Factor

IMPROVEMENT. The Correction of Low Power Factor, J. Leech-Porter. *Can. Min. Jl.*, vol. 52, no. 24, July 1931, pp. 616-618, 3 figs. Various methods for improvement of power factor conditions in industrial plants using induction motors for drive; methods for calculating returns, *i. e.*, first cost; operating costs; gross returns; net returns; points to investigate; application of methods shown for case of motorcycle company employing 104 motors ranging from 1 to 150 hp. with total rating of 1,850 hp.

Power Industry

GOVERNMENT CONTROL. Socialization or Private Enterprise, W. H. Onken, Jr. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 110-111. In reality, experience proves that notwithstanding all advantages possessed by governmental undertaking, private enterprise, in this case electric light and power corporation, more often than not renders better service at less cost; this is due to two outstanding and very obvious disadvantages of governmental enterprises, *i. e.*, political interference in operation of project and lack of incentive.

RATE MAKING. Regulation by Conference Versus Formal Rate Proceedings, L. O. Whitsell. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 108-110. Author brings to bear six years of experience in regulation by proposing that informality replace formality in rate matters and that utilities take voluntary action which will make them largely self-regulating. Before Pac. Coast Elec. Assn.

UNITED STATES. The Electric Light and Power Industry, Basic Statistical Data. *Nat. Elec. Light Assn.—Statistical Bul.*, Aug. 1931, 39 pp. Statistics contained in report embrace operations of enterprises devoted exclusively to generation and distribution of electricity, plus electric departments of all others which maintained electric light and power systems jointly with other public utility services; data were determined from reports received at N. E. L. A. headquarters from some 400 companies, whose operations represented approximately 92 per cent of entire industry.

Power Supply

SERVICE INTERRUPTION. Service Interruption for Repairs Should be Announced, H. A. Martin. *Elec. World*, vol. 98, no. 9, Aug. 29, 1931, p. 367. When extensive prearranged interruptions are necessary over period of several days, notice should be placed in newspaper in town being served that service will be interrupted and this notice should state why interruption is necessary and give definite schedule of hours and dates during which no service may be expected.

Radio

MEASURING INSTRUMENTS. Use of Automatic Recording Equipment in Radio Transmission Research, P. A. de Mars, G. W. Kenrick and G. W. Pickard. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 9, Sept. 1931, pp. 1618-1633, 10 figs. Apparatus developed for low-frequency (17.8 kc.), intermediate-frequency (770 kc.), and high-frequency (6942.5 kc.) field-intensity recording; circuits employed are discussed with particular reference to expedients for obtaining nearly logarithmic scales when used with Leeds and Northrup recording potentiometer.

RECEIVING APPARATUS — NOISES. Noise Generation Within Radio Receivers, R. de Cola. *Radio Eng.*, vol. 11, no. 8, Aug. 1931, pp. 15-17, 7 figs. Theoretical discussion of radio receiver design as related to employment of new type tubes; noises resuming from thermal agitation; shot effect; and secondary emission and ionization; thermal agitation. Before Inst. Radio Engrs.

Railroads

ELECTRIC CONTROL. La régulation par unités multiples et l'automatisme dans la marche des motrices électriques (Multiple Control and Automatic Control in Operation of Electric Driven Vehicles), L. Barbillion. *Technique Moderne*, vol. 23, no. 15, Aug. 1, 1931, pp. 517-524, 13 figs. Fundamental principles, diagram showing automatic control by reversing controller system Sprague; control by contactors of powerful modern units; Thomson Houston system; electropneumatic control of Westinghouse; use of camshaft; Sprague Thomson system as used on Paris subway with wiring diagram; Jeumont-Heidman system on same railroad.

SUBSTATIONS. Heavy-Duty Rectifiers and Their Application to Traction Substation, J. W. Rissik and H. Rissik. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 416, Aug. 1931, pp. 933-963 and (discussion) 963-982, 23 figs. As result of special problem associated with supply of d-c. to traction systems, as distinct from lighting and power systems, automatic substations technique has advanced in two widely diverging directions; whereas modern substation practise in America is characterized by almost exclusive use made of rotary convertors, European practise favors adoption of mercury-arc rectifiers; present state of development of iron-clad rectifier and its application to traction supply as reflected in more recent converting installations on Continent.

Crawler Cranes Solve Problem in Railroad Electrification, T. J. Skillman. *Elec. World*, vol. 98, no. 9, Aug. 29, 1931, p. 371, 1 fig. Erection of steel for substation, tower and miscellaneous purposes in railroad electrification work sometimes proves difficult for structures not sufficiently close to main railroad tracks to permit handling by locomotive crane; here crawler cranes have proved their value in convenience and economies.

Rating

ELECTRIC MACHINERY. Report on Rating. *Int. Electrotech. Commission—Report of mtg. of Advisory Committee*, no. 2, Stockholm, June-July, 1930. Documents from Austria, France, Germany, Japan, Poland, Sweden, Switzerland, and United States, in their respective languages.

Reactive Power

METERING. Reactive Kva. Metering—IX, E. O. Goodale. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 116-117, 5 figs. Two-element three-phase meters do not give accurate results on four-wire circuits under normal conditions.

Reactors

Design of Standards of Inductance, and the Proposed Use of Model Reactors in the Design of Air-Core and Iron-Core Reactors, H. B. Brooks. *U. S. Bur. Standards—Jl. Research*, vol. 7, no. 2, Aug. 1931, pp. 289-328, 10 figs. Useful general relations concerning self and mutual inductance of geometrically similar coils are presented and their usefulness is demonstrated.

Rectifiers

COPPER OXIDE. Metal Rectifier Applications. *Engineer*, vol. 152, no. 3947, Sept. 4, 1931, pp. 241-248, 15 figs. Best-known applications are those associated with wireless reception; but this simple method of rectification is applicable in many other directions, and currents and voltages considerably greater than those heeded for wireless reception can be dealt with.

Regulators

INDUCTION. The Application of Induction Regulators, V. C. Bryan. *Elec. Rev.*, vol. 109, no. 2805, Aug. 28, 1931, p. 316, 4 figs. Fundamental principles of apparatus which is not so generally understood, either in theory or in application.

Remote Control

POWER PLANTS. Remote-Control Switchgear at Woolwich. *Engineer*, vol. 152, no. 3940, July 17, 1931, p. 76, 3 figs. Installation of remote electrically controlled switchgear put into service at Bellwater Gate power station of Woolwich Borough Council; switchgear is designed for pressure of 6,600 volts and is electrically operated by remote control from corresponding panels on main control board situated in central position in station; cubicles are built up of molded stonework slabs reinforced by steelwork.

SIGNALS AND SIGNALING. Chicago Great Western Saves $7,000 Annually by Remote Control of Tunnel Interlockings. *Ry. Age*, vol. 90, no. 22, May 30, 1931, pp. 1071-1072, 3 figs. Increased safety and flexibility of operation, and high return on investment have amply warranted expenditure of $18,000; solution of problem; operation of system; color light signals and dual control switch machines; economies effected.

Resistors

DESIGN. The Design and Construction of a Shielded Resistor for High Voltages, R. Davis. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 416, Aug. 1931, pp. 1028-1035, 2 figs. Design of shielded resistor for use at voltages up to 60 kv.; considerations governing design are discussed in detail; construction and performance of resistor are dealt with and finally question of extending further range of such apparatus is touched upon.

Rotors

Dead Points in Old Rotors, W. L. Hurlburt. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, p. 123, 1 fig. When modernizing control equipment of some old wound-rotor induction motors equipped with slip rings and external starting resistance, dead points often develop at start if resistance is removed; leakage flux conditions should be observed.

TURBO-GENERATORS. Stresses in Retaining and Centering Rings for Turbine-Generator Rotors, R. Patterson and D. H. Harms. *Applied Mechanics (A.S.M.E. Trans.)* vol. 53, no. 9, May-Aug. 1931, pp. 79-87 and (discussion) 87-89, 10 figs. Paper before Am. Soc. Mech. Engrs., indexed Engineering Index 1930, p. 1829, from Advance Paper, no. 42, for mtg. Dec. 1-6, 1930.

Switchgear

STANDARDIZATION. A Discussion of New Standards for Switching Equipment and Insulator Units as Adopted by N.E.M.A. *Elec. Light and Power*, vol. 9, no. 9, Sept. 1931, pp. 27-29, 2 figs. Rated voltage; determination of flashover values corresponding to preferred voltage ratings; curve showing minimum wet and dry flashover values for assembled, upright, base-mounted insulators; correction factors for apparatus rated on basis of varying altitudes; theoretical minimum safe distances to ground for various voltages at 60 cycles; spacing of insulator columns for various voltages.

Telephone Relays

Characteristics of Strowger Relays, R. W. Graybill. *Telephone Engr.*, vol. 35, no. 8, Aug. 1931, pp. 25 and 28, 5 figs. Discussion of features of horizontal relay structure which may be varied to secure different performance characteristics and which account for long life of this type of relay.

Television

Television, E. H. Felix. N. Y., McGraw-Hill Book Co., 1931, 272 pp., illus., diagrs., charts, $2.50. Book explains basic processes involved in any television system and describes methods of existing systems; standards of performance requisite to commercial service are outlined, and limitations of existing methods are pointed out; gives good general survey, in not too technical language, of present situation, problems that television faces, and its probable future. Eng. Soc. Lib., N. Y.

RECEIVING APPARATUS. Standards of Performance for Commercial Television Receivers, C. H. W. Nason. *Radio Eng.*, vol. 11, no. 8, Aug. 1931, pp. 30 and 45, 2 figs. Television receiver design as distinguished from radio sound receiver design; typical selectivity curve; sensitivity characteristics and fidelity curves for television receiver.

DESIGN. The Design of a Complete Television System, C. E. Huffman. *Radio Eng.*, vol. 11, no. 8, Aug. 1931, pp. 36 and 38, 10 figs. Technical information of direct use to radio engineers who desire to master elements of television. Before Radio Club.

Testing Laboratories

MANUFACTURING PLANTS. Baltimore's High Voltage Laboratory, D. H. Rowland. *Baltimore Engr.*, vol. 6, no. 5, Aug. 1931, pp. 9-11 and 16, 6 figs. High voltage laboratory of Locke Insulator Corp., makes available to electrical industry facilities which are of greatest importance in considering future growth of electrical transmission; laboratory is capable of producing 2,500,000 volts; equipment is briefly described. Before Am. Inst. Elec. Engrs.

Transformers

OSCILLATIONS. Transformer Oscillations Caused by Damped Oscillatory Waves, L. V. Bewley. *Gen. Elec. Rev.*, vol. 34, no. 9, Sept. 1931, pp. 512-517, 8 figs. Purpose of article is to consider possibilities of building up excessive internal oscillations in transformers by means of damped oscillatory incident waves, and in particular to show effects of transformer losses and decrement of applied wave in limiting these abnormal internal voltages.

Transmission Lines

DESIGN. On the Determination of Stringing Tensions for Transmission Lines and Cables, J. W. Campbell. *Eng. Jl.*, vol. 14, no. 9, Sept. 1931, pp. 477-481. Method for finding temperature-tension relations for suspended cables; of single spans with points of support at same level, single spans with points of support at different levels, composite spans which have intermediate supporting structures; hyperbolic methods are used throughout, validity of method for sage of any magnitude is shown.

HIGH TENSION. The Louisville-Cincinnati Interconnection, H. W. Eales. *Elec. Light and Power*, vol. 9, no. 9, Sept. 1931, pp. 30-34, 13 figs. Since Oct. 16, 1930, 32,000 kw. of power were transmitted from Columbus, Ohio, steam plant of Cincinnati system to Louisville over new 82-mi., 138,000-volt transmission line; principal features of interconnection; map showing course of line is given.

LIGHTNING PROTECTION. Slow Cloud Ionization Confirms Direct-Stroke Theory, C. L. Fortescue. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 420-421. Field experiences have given firm support to theory that direct stroke rather than induced stroke is cause of transmission outrages due to lightning; discharge time precludes induced voltage; one of primary requisites of ground wire protection therefore is that ground wire shall always interpose itself as shield against oncoming strokes. Before Am. Inst. Elec. Engrs.

VIBRATIONS. Dampers Installed on "Hot" 110-Kv. Line, P. J. Ost. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 114-115, 1 fig. Electrical department of City of San Francisco will install some 10,600 vibration dampers on its Hetch Hetchy transmission line; this line is of double-circuit, steel-tower construction carrying two 110-kv. circuits of 397,500 cir. mil A.S.C.R. conductors suspended from ten-unit insulators; equipment is described.

Vacuum Tubes

The Variation of the Resistances and Interelectrode Capacities of Thermionic Valves with Frequency, L. Hartshorn. *Experimental Wireless*, vol. 8, no. 95, Aug. 1931, pp. 413-421, 5 figs. Nature of changes and their order of magnitude are considered and estimation of errors arising from usual assumptions will be possible in any given case.

DETECTOR. A Method of Calculating the Performance of Vacuum-Tube Circuits Used for the Plate Detection of Radio Signals, J. P. Woods. *Univer. Texas—Bul.*, no. 3114, Apr. 8, 1931, 71 pp., 21 figs. Complete mathematical analysis pertaining to standard signal; detection of small signals; ideal detection; limited theory of large signal detection; extension to include pure resistance loading in grid and plate circuits; power series analysis of static characteristic; analysis of detection performance of UX-201A vacuum tube. Bibliography.

HOT CATHODE. A Method of Determining the Impedance of Hot Cathode Discharge Tubes, W. F. Westendorp. *Rev. Sci. Instruments*, vol. 2, no. 8, Aug. 1931, pp. 437-446, 8 figs. By means of superposed alternating current negative resistance of hot cathode neon and mercury direct current arcs was measured and found to follow closely slope of static characteristic of neon arc and to be widely different in case of mercury arc; at same time reactance for ripple current in arc was determined.

THYRATRON. Some Characteristics of Thyratrons, J. C. Warner. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 9, Sept. 1931, pp. 1561-1568, 6 figs. Fundamental characteristics; comparison with characteristics of high-vacuum tubes to show outstanding advantages and limitations; starting characteristics; typical examples; several types of thyratrons described.

Watthour Meters

INDUCTION. The Induction Watt Hour Meter, J. L. Ferns. *Elec. Times*, vol. 80, no. 2078, Aug. 20, 1931, pp. 275-277, 5 figs. Methods of producing phase difference for friction compensation; prevention of creep; quadrature adjustment; driving torque; brake torque; temperature variations; voltage variations; frequency variations; wave form variations.

Welding

LOCOMOTIVE FRAMES. Arc Welding of Locomotive Frames—I and II, J. M. Vossler. *Welding*, vol. 2, no. 8, Aug. 1931, pp. 511-513, 7 figs. Method of filling in vees, proper selection of electrodes and relieving of strains by heat treatment are important factors in securing sound weld.

PIPE. Welding Brass and Copper Piping, D. W. Endicott. *Am. Welding Soc.—Jl.*, vol. 10, no. 7, July 1931, pp. 26-29, 6 figs. Advantages of welding construction; investigation by Linde Air Products Co., to determine most desirable type of design for joints in copper and brass tubing, best welding procedure, most suitable welding rod, weldability of joints in various positions, and relative strength of various joint designs.

JOINTS. Pipe Welding—How, When and Where to do it—III, W. Spraragen. *Welding*, vol. 2, no. 7, July 1931, pp. 450-454, 7 figs. Application of welding; fabrication of large 82-in. receiver pipe for Westinghouse cross-compound steam turbine; comparative cost of header construction; graphic representation of stress transfer in collar and vee-type joints; manufacture of pipe by automatic carbon arc process.

STEEL STRUCTURES. Structural Arc Welding Progress, A. F. Davis. *Welding Engr.*, vol. 16, no. 8, Aug. 1931, pp. 42-46, 10 figs. Paper before West. Metal Congress, previously indexed from Metal Progress, Feb. 1931.

STRUCTURAL STEEL. Welding of Structural Steel, J. Ferguson. *Am. Welding Soc.—Jl.*, vol. 10, no. 7, July 1931, pp. 39-43, 12 figs. Enumeration of 10 advantages of welding; means of which welding may be advanced; factors affecting proper fabrication of welded steel. Before Am. Welding Soc.

Welds

ANALYSIS. Dissolved Nitrogen Embrittles Weld Metal, F. R. Hensel and E. I. Larsen. *Metal Progress*, vol. 20, no. 3, Sept. 1931, pp. 44-47, 5 figs. Investigation of effect of nitrogen on properties of welds at Westinghouse Research Laboratories; analyses of welded pads; to improve arc welds materially nitrogen must be reduced below 0.05 per cent; micros showing dispersion hardening of iron nitride.

STRENGTH. The Strength of Frontal and Lateral Welds, E. Hoehn. *Engineering*, vol. 132, no. 3419, July 24, 1931, pp. 115-118, 22 figs. Lap welds may be frontal or lateral; term lateral denotes weld which runs parallel to line of action of resultant load on weld, while in frontal weld fillet stands square to resultant force; test results show that specific resistance diminishes as height of fillet increases; causes of decrease in resistance of frontal welds to tearing are explained, and empirical rule found for its variation with height of fillet. Translated from report to Swiss Boiler Owners' Assn.

Industrial Notes

220,000 Volt Transmission Line Across the Susquehanna.—The work of carrying the transmission line from the Safe Harbor hydroelectric development across the Susquehanna River is now being completed. The crossing, which is over two railroads and a mile stretch of river, is between hills some 300 feet high. There are two spans of 3,000 feet each between a tower on an island near the middle of the river and those on the high hills on either side. In all, ten cables of aluminum-steel are to cross the river. The cables will carry power over a 70 mile, 220,000 volt transmission line to the system of the Consolidated Gas, Electric Light and Power Company of Baltimore. Safe Harbor will also be interconnected with the power development of the Pennsylvania Water & Power Company at Holtwood on the Susquehanna River.

Insulators for Pennsylvania Electrification.—A large order for porcelain insulators has been placed by the Pennsylvania Railroad with the Westinghouse Electric & Manufacturing Company. These insulators will be used in the new electrification now being continued toward Washington from Wilmington. If shipped at one time this order would make a freight train of 82 cars of 30,000 pounds capacity each. According to the Westinghouse Company, the transmission system for which these insulators are ordered exceeds in magnitude any previous undertaking for railroad operation in the world and uses 132,000 volts to carry the current to the various substations.

Power-Factor Correction Condensers for P. & L. E. R. R.—An order from the Pittsburgh & Lake Erie Railroad Co., for 45 units each of 4½ kva., 2,300-volt rating, has been received by the Dubilier Condenser Corporation, New York. The units are the standard Dubilier 5 kva. units, weighing 73½ pounds, and measuring 5 by 17 by 21 inches. They are to be installed at Colona, Pa., for power-factor improvement.

New High Voltage Rectifier.—What is claimed to be the largest continuous rating of dry, metallic rectifier for a given space is included in a new line of high voltage rectifiers announced by the B-L Electric Manufacturing Company, of St. Louis. Occupying a space of only 7¼ x 2¾ x 2¼ inches, this rectifier may be given a continuous output rating of 75 watts. It will operate directly from a 115 volt a-c. line.

Will Introduce New Fuse.—Dana Harland will direct the sales of the new "AE" fuse that is being introduced to the electrical industry by the Associated Engineers Company, of Chicago. The "AE" fuse is one of a long list of electrical improvements developed by the Associated Engineers Company, of Chicago, since its organization in 1908.

New Building for Jefferson Electric Company.—Announcement has been made that a contract for the construction of a new $550,000 plant has been awarded by the Jefferson Electric Company, of Chicago, to The Austin Company, engineers and builders, of Cleveland. The site is at the southwest corner of 25th Avenue and Madison Street, in Bellwood, and comprises approximately 19 acres of property. When the plant is completed on January 15, 1932, the company will abandon its present manufacturing units at 15th and Laflin Streets and Congress and Green Streets, Chicago. The Jefferson Electric Company was formed twenty years ago and merged five years ago with the Chicago Fuse Manufacturing Company.

New Time Switch.—A new Sauter, synchronous motor time switch is announced by R. W. Cramer & Company, Inc., 67 Irving Place, New York, the outstanding feature of which is a self-starting, slow speed synchronous motor. It is designed to operate at a certain speed in exact time with the frequency from the generating station, so that any number of these switches may be used to control multiple street lighting, sign and store window lighting, off-peak water heating and other time controlled circuits, all being turned on or off at the same time. It is equipped with laminated brush type copper contacts with silver arcing tips—quick make and quick break, and can be furnished in 2, 10, 15 and 25 ampere capacities for 110/220 volts, the synchronous motor being for use on 110 volts, 60 cycles.

Trade Literature

Contact Points.—Booklet, 24 pp., "Metallurgy and Design of Contact Points." Includes tables and diagrams illustrating the standard forms of contact points and fixtures available. Fansteel Products Company, Inc., North Chicago, Ill.

Insulated Cable.—Bulletin GEA 1312, 104 pp. Presents a compilation of information on all types of rubber insulated and miscellaneous insulated cable, including data on the selection of cable. General Electric Company, Schenectady, N. Y.

Fuses.—Booklet, 18 pp. The booklet gives a history of the invention and development of the fuse. It describes fuse construction and operation, as well as maintenance, and correct selection. Tables are included giving the sizes necessary for protection of motors and other appliances. Bussmann Manufacturing Company, University at Jefferson, St. Louis, Mo.

Wood Pole Specifications.—Bulletins. Contain the new American standard pole specifications for western red cedar, northern white cedar, creosoted yellow pine, and chestnut. In each case the specifications are tentative, but the dimensions are standard, and both were approved June, 1931. Inquiries should indicate which of the four specifications are of particular interest. Naugle Pole & Tie Company, 5 So. Wabash Avenue, Chicago, Illinois.

Thrust Bearings.—Bulletin HV, 40 pp. Describes vertical and horizontal thrust bearings whose parts are to a large extent interchangeable. Only standard, self-aligning, equalizing thrust bearings are covered therein. Capacities, weights and principal dimensions are given for the usual forms of these bearings. Kingsbury Machine Works, Inc., Frankford, Philadelphia, Pa.

Distortion Factor Meter.—Bulletin F-311, 4 pp. Describes type 536-A distortion factor meter for use in determining harmonic content of broadcasting station output, and to check through the amplifier in order to determine the source of distortion. The distortion factor is read directly on the dial, and the only operations required are those of throwing the switch and adjusting a potentiometer. General Radio Company, 30 State Street, Cambridge A, Mass.

Short-Center Drives.—Catalog, 148 pp., is described as an entirely new treatise of efficient short center drives compiled by the engineering staff of E. F. Houghton & Company. The book contains charts, tables and engineering data on 5,000 standard "Vim" efficiency drives ranging from 5 to 100 horsepower. A special mineral tanned leather belting is employed in these drives. The book was originally published for use by the company's field men, to assist them in discussing and working out transmission problems with engineers, and therefore it is not for general distribution. Copies will be delivered directly by a distributor to executives and engineers, interested in transmission drives, who will send in their requests in writing. E. F. Houghton & Company, Philadelphia, Pa.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th Street, New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 50
No. 12

The JOURNAL of the A.I.E.E. for December 1931

O. E. SKINNER, *President*
F. L. HUTCHINSON, *National Secretary*

Publication Committee

E. B. MEYER, *Chairman*
W. S. GORSUCH F. L. HUTCHINSON
W. H. HARRISON H. R. WOODROW

Publication Staff

GEORGE R. METCALFE, *Editor*
G. ROSS HENNINGER, *Assoc. Editor*
C. A. GRAEF, *Advertising Manager*

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ENTERED as second class matter at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

STATEMENTS and opinions given in articles appearing in ELECTRICAL ENGINEERING are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

REPUBLICATION from ELECTRICAL ENGINEERING of any Institute article or paper (unless otherwise specifically stated) is hereby authorized provided full credit be given.

COPYRIGHT 1931 by the American Institute of Electrical Engineers.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index.

Printed in the United States of America.
Number of copies this issue—

24,000

This Month—

Front Cover

Diablo Dam, one of the three major units of the Seattle (Wash.) municipal hydroelectric development on the Skagit River. This dam is 386 ft. high and 1,200 ft. long at the crest; it will supply a plant having a proposed capacity of about 320,000 hp. at a gross head of about 330 ft.

Nerve Injuries From Electric Shock 929
By W. B. KOUWENHOVEN and O. R. LANGWORTHY

Balancing Cables by Inductive Networks 933
By M. I. PUPIN

Irregularities in Speed-Torque Curves of Induction Motors . 936

 Slot Combinations of Induction Motors 937
 By GABRIEL KRON

 Field Harmonics in Induction Motors 939
 By P. H. TRICKEY

 Skewed Slots in Induction Motors 941
 By R. D. BALL

Remote Reading of Watthour Meters 942
By A. S. FITZGERALD

Cable Temperatures at Variable Loading 944
By E. A. CHURCH

Progress is the Way Out of Depression 947
By ARTHUR W. BERESFORD

Extinguishing the Short A-C. Arc 948

 I—Oscillograph Tests on Low-Current Arcs . . . 949
 By S. S. ATTWOOD, W. C. DOW, and W. KRAUSNICK

 II—Various Factors Aid Extinction of Arcs . . . 952
 By T. E. BROWNE, JR.

 III—Insulation Material Aids Extinction of Cable Arcs . 955
 By J. SLEPIAN and A. P. STROM

—— Turn to Next Page

The Philadelphia A-C. Network System 958
By H. S. DAVIS and W. R. ROSS

Non-Linear Circuits for Relay Applications 963
By C. G. SUITS

Proximity Effect in Cable Sheaths 965
By H. B. DWIGHT

The Trend in Dielectric Research 967
By JOHN B. WHITEHEAD

Abstracts of Institute Papers—

A Study of the Three-Circuit Transformer 942
C. F. ESTWICK

Synchronous Machine Constants 961
(1) L. A. KILGORE (2) S. H. WRIGHT

Field Transients in Magnetic Systems 961
E. WEBER

Transient Oscillations in Distributed Circuits 962
L. V. BEWLEY

Harmonic Generation by Grid Circuit Distortion 966
F. E. TERMAN, D. E. CHAMBERS, and E. H. FISHER

Simultaneous Faults on Three-Phase Systems 970
EDITH CLARKE

Short Item—

New Interurban Cars Secure High Speed at Low Cost . . 932

News of Institute and Related Activities . . 971

Letters to the Editor 977

Local Institute Meetings 981

Employment Notes 989

Membership 991

Engineering Literature 993

Industrial Notes 998

Officers and Committees (For complete listing see p. 771-6, September 1931 issue of ELECTRICAL ENGINEERING.)

DO YOU wish your twelve 1931 copies of Electrical Engineering bound for permanent record purposes? (*See p. 18 advertising section.*)

ANNUAL index to Electrical Engineering for 1931 is being published in separate pamphlet form; a copy is available without charge to each member or subscriber if requested before January 15, 1932. (See announcement, *p. 22 advertising section;* order form, *p. 992.*)

DR. M. I. PUPIN, one of the Institute's nine living Honorary Members, introduces an exact theory of inductive balancing networks for submarine telegraph cables. (*See p. 933-6.*)

A NEW scheme is proposed for reading watthour meters over telephone lines. (*See p. 942-4.*)

RESEARCH in dielectrics has witnessed an unusual intensity during the past year in the study of insulating liquids. (*See p. 967-70.*)

UNUSUALLY active participation by Enrolled Students was but one of the noteworthy features of the recent Kansas City district meeting reported in full in this issue. (*See p. 973-5.*)

THAT engineers will "share generously" is evidenced by the plans already under way for participation by the Institute's Sections in the organization of local engineers' unemployment relief committees. (*See p. 975.*)

FOURTEEN technical sessions, interesting inspection trips, and special entertainment features, represent the principal attractions of the forthcoming winter convention, plans for which rapidly are assuming final form. (*See p. 971-2.*)

PROCESSES involved in the extinguishing of the short a-c. arc, as encountered in circuit interrupters and in low voltage power distribution networks, have been subjected to rather close scrutiny in a group of three articles. (*See p. 948-57.*)

IN THIS month's article of the Engineering Foundation series "Has Man Benefited by Engineering Progress?" it is stated that "the growth of understanding by the many will form the foundation for a new and greater progress." (*See p. 947.*)

UNFORTUNATE rotor and stator slot combinations in induction motors often cause serious irregularities in their operating characteristics. Some of the many angles of this perplexing situation are reviewed in a group of three articles. (*See p. 936-42.*)

THOSE concerned with the operation of electric power cables are referred to (1) a simple method of calculating cable temperatures under variable loads (*see p. 944-6*) and (2) methods for calculating sheath losses due to the proximity of electric power currents (*see p. 965-6*).

Nerve Injuries From Electric Shock

During the last few years the authors have been studying the effect of electricity upon the nervous systems of experimental animals. In this article are discussed briefly the types of changes found in the brain, the spinal cord, and in the nerve cells themselves following an electric shock.

By
W. B. KOUWENHOVEN
Member A.I.E.E.

O. R. LANGWORTHY
Non-member

Both of
The Johns Hopkins
University, Baltimore

LABORATORY experiments made at The Johns Hopkins University to determine the effect of electric shock upon living animal organisms now have reached a considerable total, and well may be divided into groups according to the specific question being studied upon the occasion of the various groups of tests. This classification is indicated in the accompanying bibliography to which the numbered references apply. The scope of the article[6] which appeared in the June 1931 issue of ELECTRICAL ENGINEERING was limited to a comparison of the final results as they affected the physical well-being of the subject of the experiment, the article in effect being supplementary to one previously published.[1] It is the aim of the present article to describe and discuss briefly the results observed by microscopic study of the central nervous system in specimens subjected to shock according to experiments previously reported. The actual changes following an electric shock as found in the brain, spinal cord, and the nerve cells themselves are outlined.

Because of their convenient size and because a rat's heart is not easily damaged by electric current these animals were used as the experimental subjects in all cases, thus making it possible to focus the attention upon the nervous system. In each case the rat was given ether before the shock was applied. Directly after death the brains and spinal cord of each rat were removed and immediately "fixed" in suitable solutions to avoid postmortem changes. This material was sliced and examined, first with the unaided eye, and later microscopically to permit a detailed study of the nerve cells. However, only a part of the material subjected to this microscopic study was derived from the experimental subjects; the nervous systems of two electrocuted men also were examined.[5]

In the first series[1,2] a number of animals were studied after being subjected to a-c. or d-c. shocks of 110, 220, 500, or 1,000 volts. The time of contact varied in each group. In that series the electrodes were applied to the top of the skull and the base of the tail. For the 110- and 220-volt circuits more serious injuries resulted from a-c. than from d-c. shock, while with a circuit potential of 500 volts, the effects of a-c. and d-c. shock were approximately equal. For circuit potentials of 1,000 volts it was clear that the d-c. shock produced a greater injury than the a-c. shock, particularly when the time of application was taken into consideration.

For the different potentials of both alternating and continuous current, rather definite characteristic abnormalities[3,4] were found in each group shocked. The d-c. shocks more often produced symptoms of irritation to the nervous system, such as convulsions, whereas many of the rats receiving a-c. shocks showed paralysis of the posterior portion of the body directly after the shock. These paralyzed animals were quiet, would not eat, and never lived longer than two or three days. These latter cases when studied after death showed an abnormally soft spinal cord; and microscopic observation of cross-sections of the cords revealed that an area of hemorrhage, extending over a relatively long portion of the cord, had severed nervous pathways. In all cases the great majority of hemorrhages in the spinal cord occurred in the areas indicated in Fig. 1, although of course some were found in other places. Similar hemorrhages but usually smaller, occurred in the region of the brain. When these existed in the region controlling respiration, they were considered responsible for the death of the animal. In some cases hemorrhages were present also in the tissues covering the brain.

In the cases of experimental animals it may be said of hemorrhages that: (1) in the nervous system they are responsible for the immediate or subsequent death of a certain group subjected to contacts with electric circuits; (2) they are much more common after contact with a-c. circuits than after contact with d-c. circuits; and (3) they increase in number with the increase of circuit potential. Hemorrhages have been found also in the brains of men who have died as the result of similar shocks. Such hemorrhages probably are caused

---

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

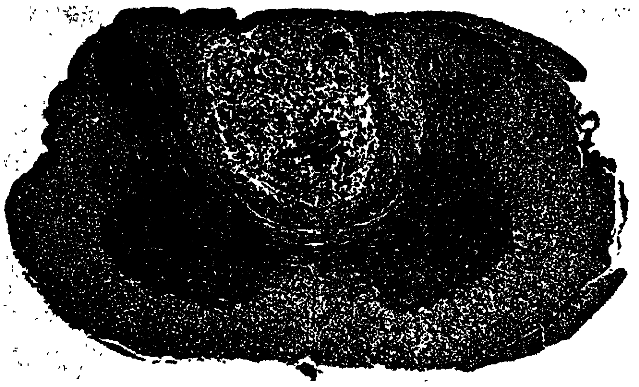


Fig. 1. Cross-section of the spinal cord of a rat

The hemorrhage which may be noted in the upper and central portions is typical of the effect which caused paralysis of the hind legs and subsequent death of the animals

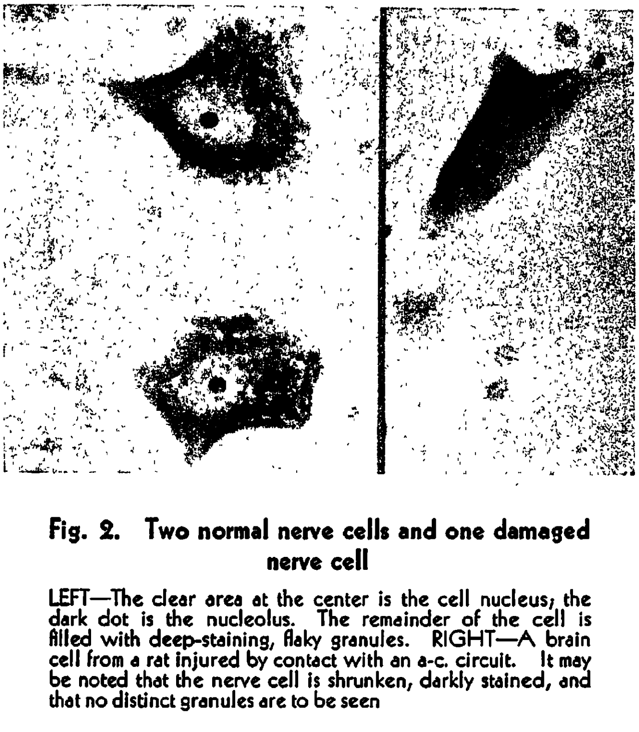


Fig. 2. Two normal nerve cells and one damaged nerve cell

LEFT—The clear area at the center is the cell nucleus; the dark dot is the nucleolus. The remainder of the cell is filled with deep-staining, flaky granules. RIGHT—A brain cell from a rat injured by contact with an a-c. circuit. It may be noted that the nerve cell is shrunken, darkly stained, and that no distinct granules are to be seen

by the sharp rise of blood pressure which follows the breaking of the contact with an electric circuit.

During the period of current flow, the blood collects in the veins, being squeezed from the heart and arteries by the contraction of the muscles in their walls. When the heart resumes its beating all this blood is forced back at once into the heart and arteries often overtaxing the capacity of the arteries and resulting in ruptures in their walls. With either a-c. or d-c. 1,000-volt circuits, severe burns often occurred around the electrode, in some cases resulting in an erosion of the skull beneath the head electrode and even burning the surface of the brain itself. (This would be a rare type of injury in man inasmuch as the head seldom lies in the direct pathway of the current.) Generally the burns from contact with a 1,000-volt d-c. circuit wree found to be more severe than those from a 1,000-volt a-c. circuit.

In this group of rats where the current passed through the head, changes in the nerve cells could be demonstrated even when animals died at once following the shock. After shocks at 500 and 1,000 volts these changes were more marked than after the lower voltage, as might be expected. In addition, they were more severe as a result of d-c. shocks than with a-c. shocks. Nerve cell damage is illustrated in several of the accompanying photomicrographic reproductions.

In making these photomicrographic studies, the finer cell structures are differentiated by staining the cells with a basic aniline dye. Certain portions of the cell have an affinity for basic dyes; others for acid dyes. In Fig. 2 the left-hand illustration shows normal nerve cells stained with an aniline dye demonstrating the characteristic granular structure of the cell. The cell edges are not regular, but are prolonged outward into angles which form the origin of nerve fibers. The clear area which always lies in the center of normal cells represents the nucleus, and near its center contains a black dot which is known as the nucleolus. Around the nucleus there are fluffy deep-staining granules which fill the remainder of the cell, always arranged in this characteristic manner with the type of cells represented in the illustrations. The granules probably are formed after death by the coagulation of some protein substance. Nerve cells injured by the passage of an electric current through the body, some from the brains of rats and others from human material, are reproduced in Figs. 2, 3 and 4.

Experience shows that all nerve cells even in a given group do not show an equal amount of damage as the result of an electric shock, several normal cells often being found among others that have suffered great changes. Extensive microscopic studies support the belief that cells having the potentialities of recovery may be differentiated from those rendered completely and permanently functionless. In this connection the nucleus is the real index of the ultimate fate of the cell; if it shows marked damage the cell will die. In the cases of experimental animals that recovered from the immediate effects of shock and were killed three or four days later, the nerve cell changes could be demonstrated with even greater clarity than in those animals which did not survive the shock. There appeared to be many cells which were permanently damaged, and others having the potentialities of recovery.

When a man suffers an electric shock which stops his breathing, artificial respiration should be continued for a prolonged period in order to give the nerve cells controlling respiration time to recover their normal functioning. Of course in the cases where changes in the nerve cells are extremely severe, recovery naturally cannot be expected, but since this cannot be predetermined the only safe and logical course is long-continued resuscitative effort.

Another question which arose had to do with the probability of injury to nerve cells when those cells did not lie in the direct path of the current. To test this question [6,7] the electrodes were shifted from one portion of the body of the experimental subject to another, and either a-c. or d-c. shocks at 1,000 volts were applied for one second. These resultant experimental findings demonstrated clearly that such contact caused damage to nerve cells only in that portion of the nervous system traversed by the current. Of course a current traversing the chest may produce serious changes in nerves controlling breathing and this injury of the nerve fibers is reflected in the cells from which they arise. It has been shown that electricity may produce a temporary block to nerve fibers as well as in nerve cells.

It is of importance to note that the type of changes produced in nerve cells by electric shocks are nonspecific and may be caused by other physical and toxic agents. Very high bodily temperature may damage nerve cells, and it is an established fact that body temperature rises rapidly in the case of electric shock if the circuit is closed for any length of time. This is supported by the results of autopsy performed on a man who suffered accidental death by contact with a 2.2-kv. 60-cycle circuit. The contact was from one arm to one leg, lasted several minutes, and badly burned the body. In this case the brain cells showed marked changes, even though that region did not lie in the direct pathway of the current. Therefore it must be considered, that if the body temperature is elevated to a considerable degree, changes everywhere in the delicate nerve cells must be expected. These changes are indistinguishable from those produced by electricity alone.

To eliminate heat as a source of nerve cell damage, several experiments were conducted using a small impulse generator[8] as the source of the electric shock. Circuit constants were so chosen that the entire duration of the surge did not exceed 4.5 microseconds, while the maximum current was about 100 amperes and the potential, 200 kv. The small amount of energy involved, coupled with the extremely short duration of the surge, produced little or no temperature rise in the animals subjected to the test. These rats were oriented in different ways with respect to the electric discharge so as to obtain results from current passage through different portions of the body. Marked changes in the nerve cells themselves were found in the brain and spinal cord of the subjects when it was traversed directly by the surge current. It is clear therefore that an electric discharge produces profound changes in nerve cells, even in cases where heating is not a possible factor. When the period of contact is prolonged, heat undoubtedly produces marked alterations.

In addition to heat there is another cause which affects nerve cells lying outside the current path. Where, for example, the contacts are at points on the same arm or leg, the passage of the electric current between these points gives rise to violent impulses which the peripheral nerves transmit to the brain. When these impulses are very strong they may produce a condition of shock akin to that perceptible after operations and fractures. This, the authors believe, is the explanation of death which occurred in several of the rats, following the passage of an electric current from hind leg to hind leg.

Injury to the nervous system resulting from electric shock has been studied recently by Morrison, Weeks, and Cobb[9] working independent of the present

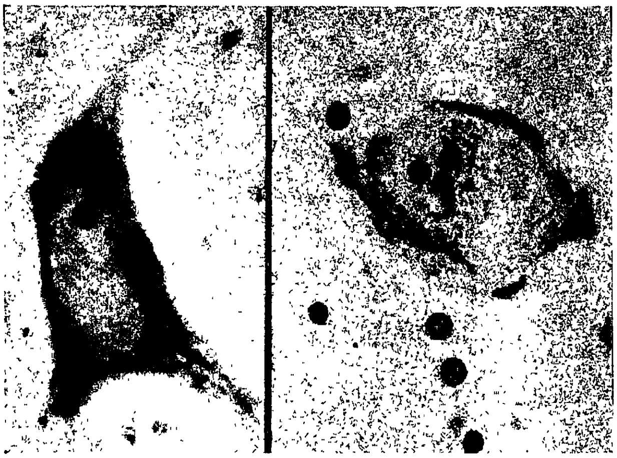


Fig. 3. Two damaged human nerve cells

RIGHT—From the brain of a man killed by a prolonged contact with a 2.2-kv. a-c. circuit. The edge of the nucleus may be noted to be irregular and to stain darker than normal; its nucleolus is swollen. There are few granules remaining in the cell. LEFT—From the brain of a legally executed twenty-four year old man. It may be noted that the nucleus edges are indistinct, the nucleolus swollen, and that there has been a loss of granules from the center of the cell

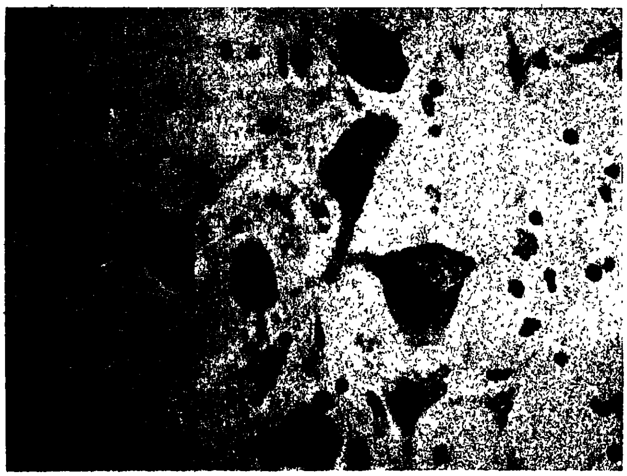


Fig. 4. Damaged human nerve cells

A group of cells from the nerve center controlling breathing, from the brain of a man killed by contact with a 2.2-kv. circuit. It may be noted that the nucleus is pushed to one side of the cell and that there are but few granules authors. Their findings agree well with those reported in this article.

The authors wish to take this opportunity to acknowledge the support given to this work by the committee on physiology of the conference on electric shocks.

BIBLIOGRAPHY

1. Effects of Electric Shock, W. B. Kouwenhoven and O. R. Langworthy, 1929. A.I.E.E. Trans., V. 49, p. 381.

2. An Experimental Study of Abnormalities Produced in the Organism by Electricity, O. R. Langworthy and W. B. Kouwenhoven, 1930. *Jl. Indust. Hyg.*, V. 12, p. 31.

3. Abnormalities Produced in the Central Nervous System by Electrical Injuries, O. R. Langworthy, 1930. *Jl. Exp. Med.*, V. 51, p. 943.

4. Histological Changes in Nerve Cells Following Injury, O. R. Langworthy, 1930. *Bul. Johns Hopkins Hosp.*, V. 48, p. 11.

5. Nerve Cell Injury in Cases of Human Electrocution, O. R. Langworthy, 1930. *Jl. A.M.A.*, V. 95, p. 107.

6. What are Effects of Electric Shock? W. B. Kouwenhoven and O. R. Langworthy. Elec. Engg., V. 50, No. 6, p. 406.

7. The Importance of the Points of Contact in Electric Injuries, O. R. Langworthy and W. B. Kouwenhoven, 1931. *Jl. Indust. Hyg.*, V. 13, p. 145.

8. The Injuries Produced by Surge Discharges, W. B. Kouwenhoven and O. R. Langworthy. *Elec. Jl.*, 1931, V. 28, No. 8, p. 472.

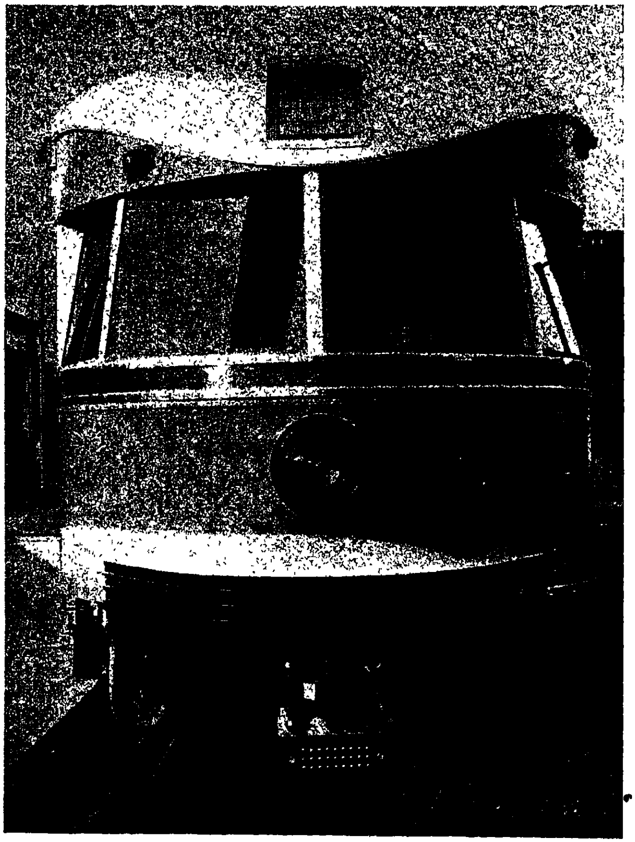
9. Histo-Pathology of Different Types of Electric Shock on Mammalian Brains, R. Morrison, A. Weeks, and S. Cobb, 1930. *Jl. Indust. Hyg.*, V. 12, p. 324.

New Interurban Cars Secure High Speed at Low Cost

TEN STREAM-LINE aluminum-body cars capable of a speed of 80 miles per hr. are being placed in service by the Philadelphia and Western Railway Company for suburban traffic. The running time of express cars from Norristown to the 69th Street station in Philadelphia, a distance of 13½ miles, is scheduled to be cut from 24 to 16 min. by these new 52-passenger cars which weigh but 25 tons and are equipped with four 100-hp. motors operating under automatic control. The cars are being constructed by the J. G. Brill Company and the electric equipment is being supplied by the General Electric Company.

Under the direction of Prof. F. W. Pawlowski, professor of aerodynamics at the University of Michigan, exhaustive wind tunnel experiments have been conducted to assist the designers in cutting air resistance to a minimum. The windows are flush with the side surfaces of the cars, the under-floor equipment is planned to reduce air resistance, the cars, on the underslung principle, have a low center of gravity, the roof is relatively low, and each end of the car has a sloping roof and pointed nose. The entire body is aluminum, with a polished aluminum "belt rail" and "skirt" running from end to end below the windows, adding greatly to appearances. Wind-tunnel tests showed that with the conventional cars operating between 70 and 80 miles per hr. more than 70 per cent of the total power is consumed in overcoming air resistance. The stream-line design of these new cars will save approximately 20 per cent of the power required to propel them at speeds above 60 miles per hr.

The weight per horsepower of the 600-volt motors has been reduced from the usual value of 30 or 35 lb. per hp. to 26.8 lb. per hp. This has been accomplished by the use of fabricated gear cases, cast-steel semi-fabricated frame heads, and modifications of motor frame design. Self-ventilation of the motors has been improved by the use of a fan mounted on the commutator end of the shaft. With the motor control system employed, starting currents are held automatically to the highest permissible values consistent with good commutation; thus every acceleration is the maximum which can be obtained successfully. This new type of high speed, light weight car providing fast and comfortable service is expected to result in increased patronage, higher schedule speed with lower platform costs, lower maintenance costs, and a saving in power consumption.



Front view of one of the new high-speed stream-line cars soon to be placed into service by the Philadelphia and Western Railway Company

Balancing Cables by Inductive Networks

Greater transmitting speeds are possible in submarine telegraph cables when balanced by inductive networks than could be obtained with the older resistance networks. In this article is presented the first exact theory of inductive balances of which two already are in successful practical operation.

By
M. I. PUPIN
Honorary Member A.I.E.E.

Columbia University
New York, N. Y.

ELECTRICAL BALANCING of submarine cables by a network of conductors for purposes of duplex telegraphy is an old art. As long as these cables had a fairly high resistance, as they did in earlier years, their signaling speed was necessarily low. Under these conditions a satisfactory balancing network, the well known artificial line, consisted of resistances connected in series, and capacitances connected from ground to each junction of two consecutive resistances. This network was the equivalent of a sectional conductor, each section having resistance and capacitance, but no inductance; electrical reactions of the network imitated the electrical reactions of the cable. At low signaling speed such a network gave satisfactory results when its sections were sufficiently small and when a sufficiently large number of sections was used.

In recent years long submarine telegraph cables of low resistance have been laid for the purpose of increasing the speed of signaling. The heavy cable laid eight years ago by the Commercial Cable Company between Canso, Nova Scotia, and the Azores has a resistance of only about one ohm per nautical mile; it was intended to transmit at the rate of 600 letters per minute. At this speed, however, the inductance reaction of the cable came into play and the old balancing network containing no inductance in its sections could not balance it. In duplex working this heavy cable had to be operated at a much lower speed to accommodate the non-inductive balancing network. The design of an efficient inductive network thus became a very important problem in the operations of this long low-resistance cable.

EARLIER INDUCTIVE NETWORKS

Even a superficial study of this problem made obvious the fact that the old balancing artificial line had to be changed by introducing in its sections suitable inductive elements in place of the simple resistances. It was obvious also that within a certain frequency interval the effective inductance and resistance of these elements must vary with frequency, simulating the variations of effective inductance and resistance of the corresponding sections of submarine telegraph cable which was to be balanced. This seemed to introduce into the problem an insurmountable difficulty.

Breisig (*Electrotechnische Zeitschrift,* November 1899) and, twenty years later, Pernot (*Journal Franklin Institute,* September 1920; *British Patent Specification,* 1922) discovered that the effective inductance and resistance of a submarine cable section vary with frequency somewhat like the effective inductance and resistance of the primary of a transformer with its secondary short circuited. This discovery led to several attempts to imitate in the balancing network the electrical reactions of a cable by inserting in the sections of the old artificial line, transformers with short-circuited secondaries or their equivalent, that is, inductance short circuited by a non-inductive resistance or by another inductance. The most noteworthy among these attempts were those of Murihead Company and Davis (*British Patent Specification* 216, 219, March 24, 1924) and of Gilbert (*U. S. Patent,* 1,533,178, April 1925). No results ever have been published

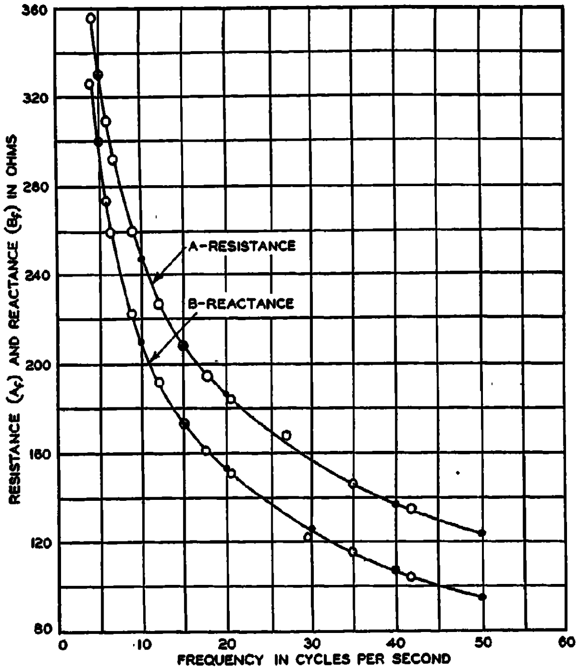


Fig. 1. Effective terminal resistance (A) and reactance (B) for a typical submarine telegraph cable (circles) and for the inductive network designed to balance it (dots)

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

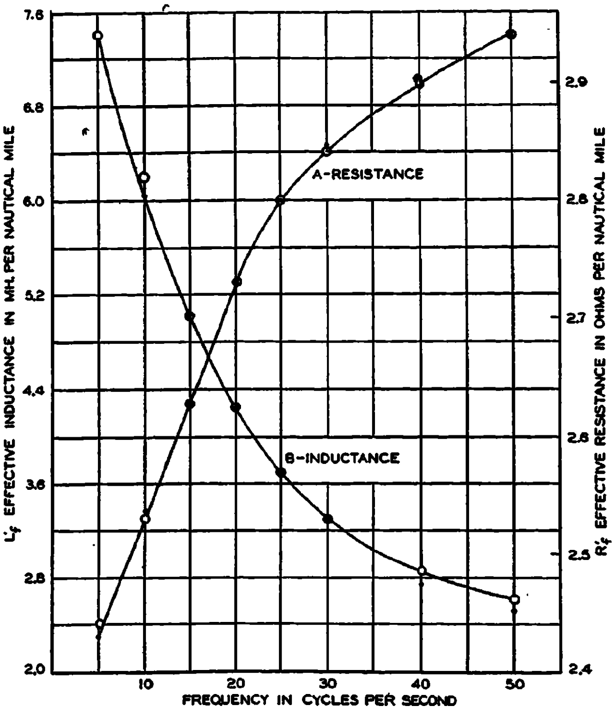


Fig. 2. Effective resistance (A) and inductance (B) per nautical mile for "equivalent" cable (circles) and for the network designed to balance it (dots)

which show how these applications of the old ideas of Breisig and Pernot succeeded in practise. It will be shown presently, however, that these applications cannot lead to a satisfactory balancing network since each section in such a network must be free from external electromagnetic disturbances. This means that the network inductances must have no stray fields in order to avoid mutual induction with the inductances in adjacent sections and with other external circuits.

Murihead Company and Davis, as well as Gilbert and others, not only overlooked this important provision, but, moreover, they *recommended* inductances with stray fields; the theory which they followed is not applicable to their structures since they invariably employed inductive elements having mutual induction not only with external circuits but also between sections of their networks. No mathematical theory of such networks exists, and just what are the determining factors in their design, is not clear.

Inductive Network With No External Field

In the following paragraphs will be discussed inductive networks having in their sections inductance coils with no external magnetic fields. In such networks the sections have no mutual induction with each other nor with external circuits; they are, therefore, free from external electromagnetic disturbances.

In a submarine cable which already is laid, the only quantities that can be measured are its terminal reactance and resistance at various frequencies. These measurements were made on a typical cable and formed the foundation of the study discussed here.

Curves A and B of Fig. 1 represent at various frequencies the effective terminal resistance a_f and the effective terminal reactance b_f of a cable as determined by wheatstone bridge measurements. The cable is one belonging to the Commercial Cable Company and connects Far Rockaway, Long Island, with Canso, Nova Scotia. Its constants are

Length.............. $l = 974.83$ nautical miles
Average capacity..... $c = 0.384$ μf. per nautical mile
Average copper resistance................ $r = 2.45$ ohms per nautical mile

Submarine cables are not of the same size at each point in their length; shore ends are much larger than deep sea parts, and hence the effective capacity and the effective inductance vary from point to point. The cable just referred to thus is not uniform, but a uniform cable which at all frequencies will have the same terminal reactance and resistance as this cable can be designated in theoretical studies; call it the *equivalent cable*. It can be specified as follows: Let C_f', R_f', and L_f' be the capacity, resistance, and inductance respectively per unit length of this equivalent cable at frequency f. Then if it is to have the same terminal reactances and resistances at various frequencies as those recorded in Fig. 1

$$a_f - i\,b_f = \sqrt{\frac{L_f'}{C_f'} - \frac{i\,R_f'}{p\,C_f'}}$$

or

$$(a_f^2 - b_f^2)\,C_f' = L_f'; \quad 2\,p\,a_f\,b_f\,C_f' = R_f' \qquad (1)$$

where $p = 2\,\pi\,f$

Make C_f' independent of the frequency and equal to 0.384 μ f., the same as the average capacity per unit length of the Far Rockaway-Canso cable. From eqs. 1 and curves A and B of Fig. 1, the effective resistances R_f' and inductances L_f' of the equivalent cable were calculated. From these calculations curves A and B of Fig. 2 were plotted for the frequency interval between 5 and 50 cycles per second.

An inductive network which can balance this equivalent cable obviously will balance also the original cable. Such a network will balance the equivalent cable at every frequency for which the effective inductance and resistance in its sections are the same as in the corresponding lengths of the cable. The aim of this study was to design a balancing network of this kind, employing in its sections inductance coils possessing no external fields. Several methods of construction were found to give very satisfactory results. The simplest of these is described here in some detail.

Network of Inductances in Series

The network discussed here employs in each of its sections two inductance coils connected in series as shown by coils 3 and 4 of Fig. 3. Each coil is toroidal in shape and thus has no external magnetic field; one is shunted by a simple resistance R_1. The unshunted coil has inductance l_0 and resistance r_0. Let L be the inductance of coil 4 and R its resistance, without the shunting resistance R_1. Then it can be shown that at frequency 10 s, and with coil 4 shunted by resistance R_1, the effective inductance L_{10s} and the effective resistance R_{10s} of the two coils connected in series will be

$$L_{10s} = \frac{L\,(1-a)^2}{1+s^2\,a_0^2} + l_0; \quad R_{10s} = \frac{(a+s^2\,a_0^2)R_1}{1+s^2\,a_0^2} + r_0 \tag{2}$$

Where $a = \dfrac{R}{R+R_1}$ and $a_0 = \dfrac{2\,\pi \times 10\,L}{R+R_1}$

At frequencies 10 s = 20 and 10 s = 30

$$L_{20} = \frac{L\,(1-a)^2}{1+4\,a_0^2} + l_0; \quad R_{20} = \frac{(a+4\,a_0^2)\,R_1}{1+4\,a_0^2} + r_0$$

$$L_{30} = \frac{L\,(1-a)^2}{1+9\,a_0^2} + l_0; \quad R_{30} = \frac{(a+9\,a_0^2)\,R_1}{1+9\,a_0^2} + r_0$$

Hence

$$\frac{L_{20}-L_{30}}{R_{30}-R_{20}} = \frac{L\,(1-a)}{R_1} = \frac{L}{R+R_1} = \frac{a_0}{2\,\pi \times 10} \tag{3}$$

As may be seen later eq. 3 has proved very useful in the theory of the design of inductive balancing networks.

If curves are plotted for L_{10s} and R_{10s}, the inductance and resistance curves given by eq. 3, then for the frequency interval from 10 s = 5 to 10 s = 50 the inductive network will balance the equivalent cable to the extent, only, that these curves coincide during that interval with curves A and B of Fig. 2. The problem of this study is, therefore, to adjust the physical constants of coils 3 and 4 (Fig. 3) so that within this frequency interval the curves for L_{10s} and R_{10s}, as given by eqs. 2 coincide as nearly as possible with curves A and B of Fig. 2. The frequency interval between 5 and 50 cycles per second is considered here because it is the important interval at the signaling speeds of the cable under consideration, that is, 600 letters per minute.

Assume that these curves coincide at frequencies 20 and 30, and that each section of the inductive network represents ten nautical miles of the equivalent cable; then

$$\left.\begin{array}{l} 10\,L_{20}' = L_{20};\ 10\,L_{30}' = L_{30} \\ \text{and} \\ 10\,R_{20}' = R_{20};\ 10\,R_{30}' = R_{30} \end{array}\right\} \tag{4}$$

Under what conditions will these coincidences occur? It will be shown presently that equation

$$\frac{L_{20}-L_{30}}{R_{30}-R_{20}} = \frac{L_{20}'-L_{30}'}{R_{30}'-R_{20}'} \tag{5}$$

determines these conditions completely, because (see eq. 3) it assigns definite values to all of the physical constants in eq. 2. These constants are: a_0, l_0, R_1, R, r_0, and $a = R/(R+R_1)$. The assumptions (eq. 4) leading to eq. 5 are, therefore, the foundation for the procedure of designing the inductive network considered here.

The right-hand member of eq. 5 has, according to Fig. 2, a definite numerical value equal to 1/109 approximately. The left-hand member of eq. 5 is equal to $a_0/(2\,\pi \times 10)$ according to eq. 3. Hence

$$a_0 = \frac{2\,\pi \times 10}{109} = 0.576$$

and

$$a_0^2 = 0.332$$

This constant a_0 in the equations of the inductance and resistance curves of the network is therefore fixed by experiment. The other constants in eqs. 2 also are definitely fixed by experiment as follows:

$$\frac{L_{20}-l_0}{L_{30}-l_0} = \frac{10\,L_{20}'-l_0}{10\,L_{30}'-l_0} = \frac{1+9\,a_0^2}{1+4\,a_0^2}$$

Whence l_0 = 18.30 mh.

Again from eq. 2

$$(1-a)^2\,L' = \frac{(10\,L_{20}'-l_0)\,(1+4\,a_0^2)}{L} = 56.57 \text{ mh.}$$

Having selected a convenient value for L, the inductance of the shunted coil without R_1, the constant $a = R/(R+R_1)$ also is fixed. It is 0.387 when L = 0.15 henrys. Since

$$1-a = \frac{R_1}{R+R_1} = \frac{R_1\,a_0}{2\,\pi \times 10\,L} = 0.613$$

$$R_1 = \frac{2\,\pi \times 10\,L \times 0.613}{a_0} = 10.0 \text{ ohms}$$

$$R = \frac{a\,R_1}{1-a} = 6.3 \text{ ohms}$$

$$r_0 = 10\,R_{20}' - \frac{(a+4\,a_0^2)\,R_1}{1+4\,a_0^2} = 20.0 \text{ ohms}$$

If therefore the physical constants of the two inductance coils in the sections of the inductive network have the values which have been calculated by means of eq. 5, then the inductance and resistance values will

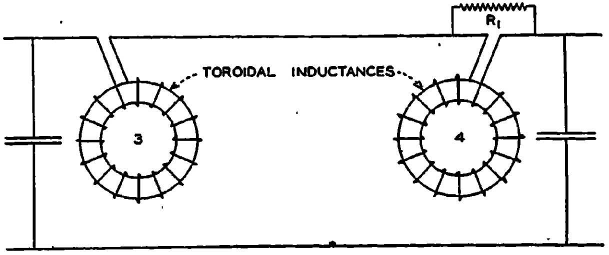


Fig. 3. Schematic diagram of a section of inductive balancing network with no external magnetic field

be as indicated in eqs. 4. The question now arises as to how the effective inductance and resistance curves of the two structures compare at other frequencies. This comparison is obtained easily by substituting successively different values of frequency from $10\,s = 5$ to $10\,s = 50$ in the following equations:

$$\left.\begin{aligned} L_{10s} &= \frac{56.57}{1 + 0.332\,s^2} + 18.3 \\ R_{10s} &= 20.0 + \frac{(0.386 + 0.332\,s^2)\,10}{1 + 0.332\,s^2} \end{aligned}\right\} \quad (6)$$

These equations are obtained by inserting in eqs. 2 the values of the constants just calculated.

The values of inductance and resistance thus calculated from eqs. 6 were plotted by dots in the curves of Fig. 2. The overlapping of the effective inductance and resistance curves of the equivalent cable with those of the inductive network certainly is remarkable. However, the overlapping of the terminal reactance and resistance curves is even closer as is indicated by curves *A* and *B* of Fig 1. In these curves the small circles denote values determined by wheatstone bridge measurements on the cable and referred to previously, while the dots denote values calculated by eqs. 1 from L_{10s} recorded on curves *A* and *B* of Fig. 2, and verified later experimentally by measurements on the inductive balancing network after this had been constructed.

Since the terminal impedance curves of the inductive network and of the equivalent cable coincide within the frequency interval between 5 and 50 cycles per second it follows that the network will balance the cable within that frequency interval. Practical operations are in complete agreement with this theoretical result. The same method of procedure was followed in the design and construction of inductive network balances of this type for other cable terminals, and in each case the result was just as satisfactory as in the case just described.

Irregularities in Speed-Torque Curves of Induction Motors

Recent investigations have thrown light on the hither to obscure causes of "cusps" in the speed-torque curves of polyphase induction motors, causing the motors to "crawl" at reduced speed or to be noisy and to vibrate under load. Results of some of these studies are described in the three articles following the introduction below.

SPEED-TORQUE curves of polyphase induction motors on test never have agreed with the smooth calculated characteristics. As a result of these unpredictable "hooks" or "cusps" in the speed-torque curve, some motors are found to crawl at unexpected speeds or are so noisy as to be useless for all practical purposes. Various explanations have been advanced as to the cause of these irregularities, but no satisfactory method of definitely predetermining the speed-torque curve could be found.

Certain factors, such as the harmonics in the revolving field caused by the distributed winding, or the relative number and shape of the stator and rotor slots, are known to influence the shape of the curve. However, dependence upon empirical rules for the selection of rotor slots always has been necessary. Rules such as the use of twice a prime number for rotor slots, or the avoidance of less than 20 per cent difference in stator and rotor slots, have passed from one designing generation to the next. A German engineer, Dr. W. Stiel, published other empirical rules devised from an extensive investigation of a large variety of slot combinations. As is to be expected, all these empirical rules not based on a knowledge of the disturbing phenomena often result in unpleasant surprises. Hence today manufacturers are led to the wasteful method of building a series of rotors with different slots whenever a new line of induction motors is required, to find by actual test which of the rotors is most satisfactory.

In the first two of the following three articles, attempts are made to determine the cause of the irregularities in the speed-torque curves, and to formulate rules for the prediction of these characteristics. The first article, by Kron, gives consideration to the slot combinations in the stator and rotor and indicates that the most powerful disturbing effects are due not to the distribution of windings in slots, but to the existence of the slot openings in the stator and rotor. As the result of a careful, mathematical analysis based on a new method of attack, involving the concept of "revolving permeances," definite rules are laid down by the author regarding the occurrence of vibration, noise, and crawling of induction motors. The second article, by Trickey, is concerned with the effect of harmonics in the rotating field, and the results, while not entirely in agreement with those in the first article, appear to be well substantiated by test. A possible explanation of the apparent discrepancy between these two investigations is that the first is concerned with rotors having a small number of slots so that the slots are relatively important, while the second deals more particularly with rotors having a large number of slots so that the slots become less important and the harmonics in the field have an increasing influence.

The third article of this group is a contribution from England, and gives the derivation of a formula for determining the short-circuit current obtained with skewed rotor slots in per cent of the short-circuit current obtained without skewed slots. By its use, the value of short-circuit current may be predicted for any angle of skew of the rotor slots. While this subject is somewhat controversial, it is of interest in connection with the other two articles, as skewing is resorted to in an effort to eliminate noise and crawling of induction motors at reduced speed.

Slot Combinations of Induction Motors

By
GABRIEL KRON
Associate A.I.E.E.

United Research Corp.,
Long Island City, N. Y.

AMONG the suggestions advanced as to the cause of irregularities in the shape of the speed-torque curves of polyphase induction motors which cause them to crawl at reduced speeds or to have excessive vibration and noise, is that the harmonic fluxes introduced by the distribution of the stator and rotor windings in slots may cause these irregularities. However, the conclusions of this analysis are not borne out by the facts, and the investigations on which this article is based show that the most powerful disturbing effects are due not to the distribution of the windings, but to the presence of the slot openings in the stator and rotor.

The existing methods of analyzing the influence of slot openings were found to be unsuitable for this particular problem, so another method of attack was devised, introducing the concept of "revolving permeances" to find what fluxes exist in an induction motor besides the fundamental flux when both stator and rotor are slotted, and what is the speed of these parasitic fluxes as the rotor rotates at any particular speed. With this conception and the general term of Fourier's series, the necessary rules and formulas may be expressed in simple forms.

REVOLVING PERMEANCES

It will be assumed that the slots are replaced by *effective* slots having rectangular shapes, as in Fig. 1(a), and that the lines of flux are parallel in the gap. To avoid the disturbing use of subharmonics and fractional harmonics, a flux with one pair of poles (two poles) will be called the first harmonic and a flux with p pairs of poles will be called the pth harmonic.

Let first both stator and rotor teeth be removed. The resulting gap has a constant permeance $\mathcal{P}_c$ and is represented in Fig. 1(b) by unit height.

Next, let the stator teeth be introduced. At those points around the circumference where stator teeth exist, the permeance increases. This change of permeance can be considered as if an additional stationary permeance, $\mathcal{P}_s$ consisting of rectangles, has been introduced. If the number of stator teeth is G_1, this permeance $\mathcal{P}_s$ can be expressed as a constant term plus a series of harmonic permeances $\Sigma A_k \cos k G_1 x$ where k is any integer. The largest of these is $A \cos G_1 x$, the harmonic permeance having G_1 pairs of poles.

Let now the stator teeth be removed and the revolving rotor teeth, G_2 in number, be introduced. This is equivalent to introducing an additional revolving permeance $\mathcal{P}_r = \Sigma B_k \cos (k G_2 x - v k G_2 \omega t)$ where v is the ratio of the rotor speed to the two pole synchronous speed S. (S is 3,600 with 60 cycles.) The speed of each of these permeances is $v k G_2/k G_2 = v$. The largest permeance is $B \cos (G_2 x - v G_2 \omega t)$, the one with G_2 pairs of poles.

If the stator teeth are *not* removed when the rotor teeth are introduced, at those points along the circumference where no stator teeth exist, the additional permeance is $\mathcal{P}_r$, same as above, but at those points where stator teeth do exist, the additional permeance is larger than $\mathcal{P}_r$ by the amount of an oscillating permeance $\mathcal{P}_o$. This permeance $\mathcal{P}_o$, due to the coexistence of slots, is much larger than $\mathcal{P}_s$ or $\mathcal{P}_r$. In decreasing the air-gap, $\mathcal{P}_s$ or $\mathcal{P}_r$ change very slightly, but $\mathcal{P}_o$ increases very rapidly.

As the rotor revolves, each part of $\mathcal{P}_o$ describes a peculiar cycle. The width of each rectangle increases from zero to a definite value, then moves along the

---

Based upon "Induction Motor Slot Combinations" (No. 31-46) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 26-30, 1931.

periphery, soon decreases and finally disappears. In spite of its complicated behavior it can be expressed easily in a Fourier's series by noting that if two series representing $\mathcal{P}_s$ and $\mathcal{P}_r$ are multiplied together the product represents the oscillating permeance $\mathcal{P}_o$. Hence

$$\mathcal{P}_o = \Sigma C_k \cos[(k_1 G_2 \pm k_2 G_2) x \pm v k_2 G_2 \omega t]$$

The largest among these revolving double-infinity harmonics is the one having $(G_1 - G_2)$ pairs of poles,

$$\mathcal{P}_o = C \cos[(G_1 - G_2) x + v G_2 \omega t]$$

revolving with a speed $[G_2/(G_1 - G_2)] v$. If G_2 is larger than G_1 this permeance revolves forward; if smaller, it revolves backward. With decreasing air-gap $\mathcal{P}_o$ increases rapidly and may reach a value of the same order of magnitude as the constant gap. It is this very permeance which causes most of the trouble.

Now, if p equals the number of pairs of poles of the stator winding, and an m.m.f. wave $M = M_r \cos(p x - \omega t)$ exists in the stator, it produces with each of the permeances two fluxes since flux = m. m. f. × permeance. Based on this theory rules can be formulated as to the behavior of induction motors with regard to crawling, vibration, and excessive noise. These rules, summarized below, have been substantiated by many tests and indicate that the assumption of rectangular rotor slots is justified.

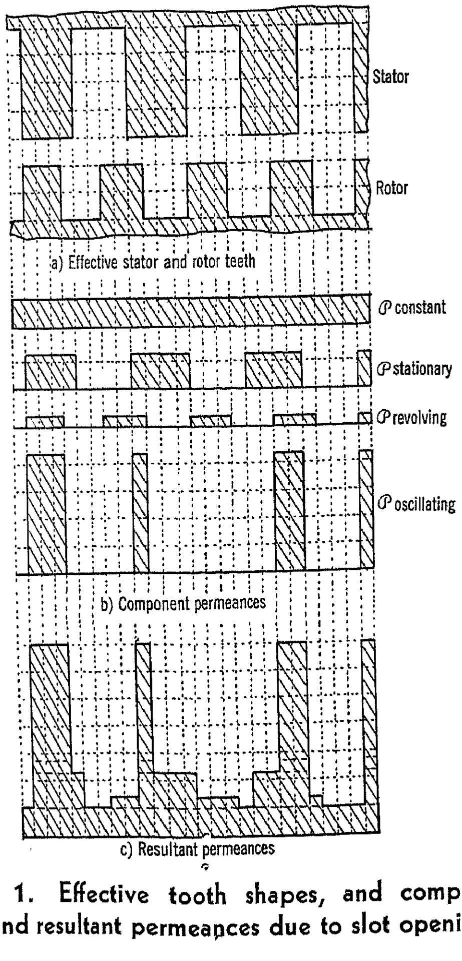


Fig. 1. Effective tooth shapes, and component and resultant permeances due to slot openings

SUMMARY OF RULES

A. Vibration and noise are liable to be present under the following conditions.

1. When the slots differ by one or by the number of poles plus or minus one, the fundamental m. m. f. and the oscillating permeance produce a flux differing by two poles from the fundamental flux. When the speed of the resulting unbalanced pull is the same as the critical speed of the rotor, circular vibrations and noise occur.

2. When the slots differ by half the number of poles, the fundamental m. m. f. and the oscillating permeance produce a fundamental single-phase flux. When the frequency of torsional vibrations is the same as the critical frequency of the rotor, torsional vibrations and noise occur.

3. When the slots differ by the number of poles the fundamental m. m. f. and the oscillating permeance produce a parasitic fundamental flux revolving with a different speed than the fundamental flux. These two fluxes set up torsional vibrations and noise, and also rumbling noises unaccompanied by critical vibrations.

The chances that the noise occurs in the working range are greater with smaller number of poles, higher speed and with smaller critical speeds. When these noises do occur, the motor is practically useless.

B. Crawling may be present under the following conditions.

1. When the slots differ by the number of poles and the rotor has more slots than the stator, the fundamental m. m. f. and the oscillating permeance produce a parasitic fundamental flux. At a rotor speed $S\,(2/G_2)$ the speed of the parasitic flux is the same as the speed of the fundamental flux, the two fluxes lock and the motor crawls as if it were a synchronous motor (reaction machine effect). When the rotor has less slots, the synchronous crawling occurs at a negative speed.

2. When the rotor slots are greater than $(G_1 + p)$ by, say 80 per cent, the fundamental m. m. f. and the stator slot-opening produce a flux having less poles than the number of rotor bars. At a rotor speed $S/(G_1 + p)$ the motor crawls due to induction motor effect.

3. When the rotor slots are greater than $(G_1 - p)$ by, say 80 per cent, crawling occurs at $S/(G_1 - p)$ if driven backward, due to the same reason as in 2.

4. When the rotor slots in a two-phase motor are divisible by the number of poles, the fifth harmonic flux due to the distribution of winding may cause crawling at one-fifth synchronous speed.

5. Any two-phase motor may crawl at one-third synchronous speed if driven backward, due to the backward revolving third harmonic flux caused by the distribution of windings.

6. When $G_2/2\,p$ is an integer equal to or close to unity, crawling may occur at S/G_2 due to the "Görges" effect.

7. When the vibrations under *A* occur at low speeds, the motor crawls.

8. When the harmonic flux, due to the distribution of winding, is large, say larger than 10 per cent of the fundamental, the motor may crawl.

C. Smaller irregularities and hooks in the speed-torque curve may appear under the following conditions.

1. When the rotor slots are greater than $(G_1 + p)$ a hook occurs at $S\,(G_1 + p)$ r. p. m.

2. When the rotor slots are greater than $(G_1 - p)$ a hook occurs at $S/(G_1 - p)$ r. p. m. if the motor is driven backward.

3. When the rotor slots are divisible by the number of poles, a hook occurs at S/G_2 r. p. m.

4. When the rotor slots are divisible by the number of poles, a hook occurs at one-seventh synchronous speed in a three-phase motor and at one-fifth synchronous speed in a two-phase motor. In both cases, the hook is accompanied by another hook at S/G_2 r. p. m.

5. When $G_2 = 2\,p\,(1 + k\,\psi)\,2\,p$, where ψ = number of phases, a small synchronous locking (synchronous motor) effect occurs at $S\,(2/k_2 G_2)$ r. p. m.

6. Any two-phase motor has a hook at one-third synchronous speed if it is driven backward.

7. When a winding introduces a harmonic flux larger than, say 8 per cent of the fundamental, it always produces a hook.

8. When the vibrations under A occur at higher speeds, proportionally smaller hooks occur at those speeds.

It should be emphasized that these rules are not necessarily complete. Those for smaller noises, which make the motor useless only for certain applications, are not considered at all in this article, neither are the variations of torque during starting and at very low speeds.

Field Harmonics in Induction Motors

By
P. H. TRICKEY
Associate A.I.E.E.

Westinghouse Elec. & Mfg. Co., East Springfield, Mass.

CUSPS in the speed-torque curves of induction motors have been attributed to several causes; first, to harmonics in the rotating field; second, to the synchronous locking-in of stator and rotor harmonics as shown by Dreese; and third, to the effect of the slot openings as shown by Kron. The present article is devoted exclusively to the study of the first cause, and indicates that harmonics in the field form do have a very definite effect on the speed-torque curve.

It may be assumed that each harmonic of the rotating m.m.f. causes a proportional rotating flux, and that each of these flux harmonics acts in the motor as if it were present alone. It then produces a small speed-torque curve whose torque is proportional to the fundamental torque, and whose speed is l/h times the speed of the fundamental for the same slip, where h is the order of the harmonic. On this basis,

$$T_h = h\,K_h^2\,C^2\,K^2\,T_1$$

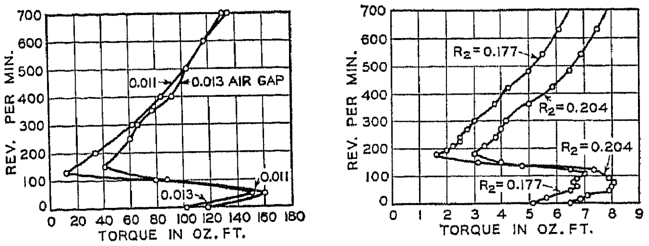
where

T_h = harmonic torque
K_h = magnitude of harmonic m.m.f. as a fraction of the fundamental
C = skew factor
K = distribution factor, dependent on the number of rotor bars
T_1 = fundamental torque at the same slip

As the harmonic torques do nothing but harm, they are eliminated or made as small as possible in normal design. K_h the magnitude of the harmonic m.m.f. is reduced by making the revolving field as nearly sinusoidal as possible. C may be reduced to zero for any one harmonic by skewing through twice the harmonic pole pitch. K is a function of the number of rotor bars, and is based on the fact that most induction motor theory is developed assuming an infinite number of bars. This brings a distribution factor of 0.637 into the formulas. With even as few as four bars per pole this factor changes little, but for the harmonic fields, the number of rotor bars per pole may be one or less. With one bar per pole K equals 2.46 and with one bar for two poles it becomes zero. However, since small numbers of rotor bars may bring in dangerous synchronous cusps, it is safer to use a large number of rotor bars, and when K begins to approach its maximum value, control by the skew factor.

There are three other means of reducing the cusps that are not apparent from the equation. First, the equation assumes that the flux wave is exactly the same as the m.m.f. wave. However, increasing the air gap will smooth out the harmonics, as indicated by Fig. 2. Second, the slot openings tend to increase certain of the harmonics, and therefore the openings should be made as small as possible. Third, while the magnitude of the harmonic torque is not reduced by increasing the rotor resistance, the fundamental torque is increased, and the resultant minimum torque is much greater. A typical case is shown in Fig. 3.

In order to study the effect of field harmonics, a special motor was built. A 48-slot primary was used to give sufficient slots per pole for the special windings, and to reduce the effect of slot openings, as the coil angle covered two or more slots. The rotor was chosen with 60 slots, a multiple of three to eliminate any possibility of the synchronous effect noted by Dreese, and of a greater number of slots than the stator to reduce "cogging" and to avoid possibility of the unlucky combinations that have occurred so many times with small numbers of rotor slots.



Figs. 2 and 3. Test curves of effect of increasing air gap (left) and secondary resistance (right)

Four separate windings were placed in the stator, all of different wave forms, and so located that their fundamental fluxes coincided exactly. The windings were all three-phase, four pole, 60 cycles, and designed for the same fundamental flux. The wave analysis of each winding is given in Table I, the meaning of the

---

Based upon "Cusps in the Speed-Torque Curves of Induction Motors" (No. 31-71) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

positive and negative signs being indicated in Fig. 4. The four separate windings were arranged as follows:

Winding *A*	Two slots per phase per pole, full pitch
Winding *B*	Two slots per phase per pole, two-thirds pitch
Winding *C*	One slot per phase per pole, full pitch
Winding *D*	One slot per phase per pole, two-thirds pitch

This motor very clearly illustrates the effect of changing the wave form. Figs. 5, 6, 7 and 8 are the test curves of windings *A*, *B*, *C*, and *D* respectively. The speed-torque curves for windings *A* and *B* shown in Figs. 5 and 6 are nearly alike except for a difference

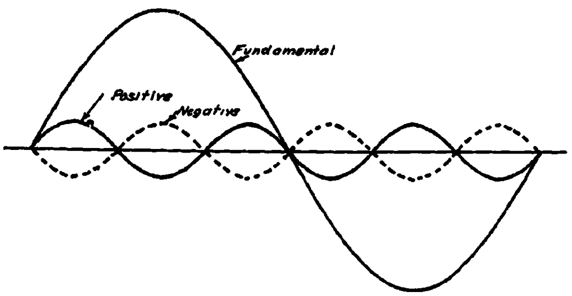
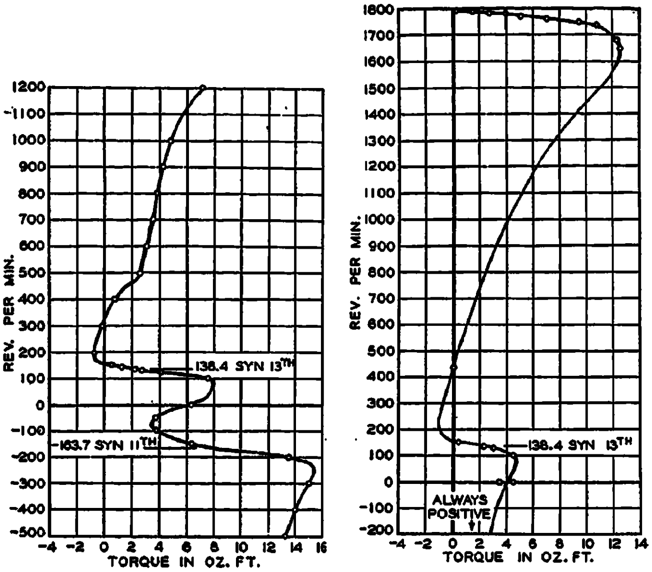


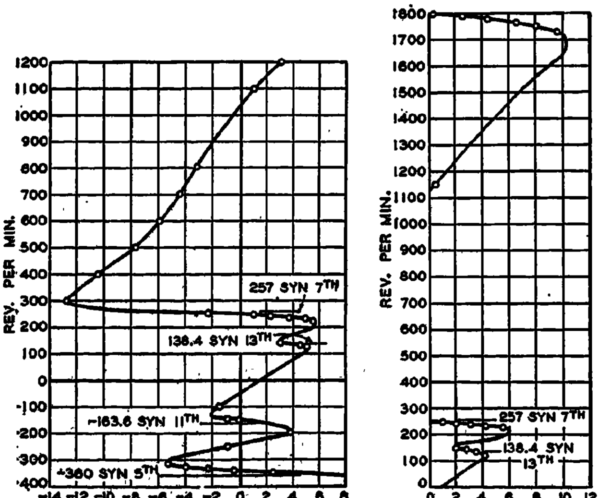
Fig. 4. Meaning of positive and negative signs of m.m.f. analysis presented in Table I

Table I—Magnitude of M.M.F. Wave—Per Cent

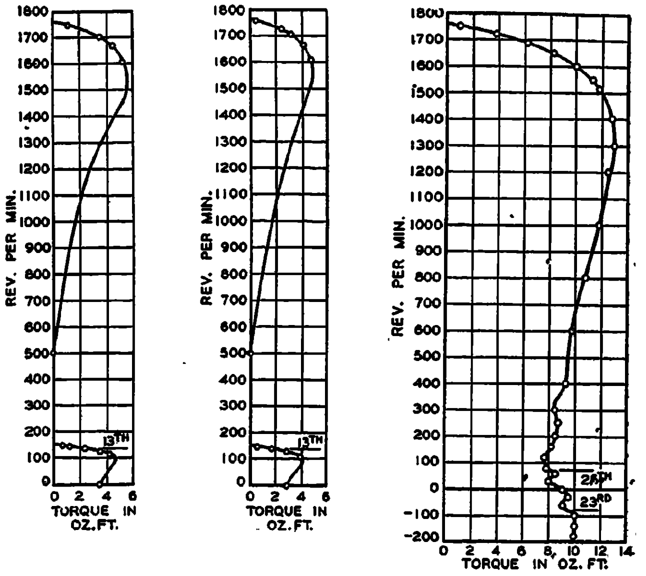
h Rot.	1 For.	5 Back.	7 For.	11 Back.	13 For.	17 Back.	19 For.	23 Back.	25 For.
Wdg.									
A	+100	+ 5.37	− 3.84	−9.1	−7.7	−1.58	+1.41	+4.35	+4.00
B	+100	− 5.37	+ 3.84	−9.1	−7.7	+1.58	−1.41	+4.35	+4.00
C	+100	+20.	+14.3	+9.1	+7.7	+5.88	+5.26	+4.35	+4.00
D	+100	−20.	−14.3	+9.1	+7.7	−5.88	−5.26	+4.35	+4.00
A+*B*	+100	0	0	−9.1	−7.7	0	0	+4.35	+4.00
C+*D*	+100	0	0	+9.1	+7.7	0	0	+4.35	+4.00
A+*B*+ *C*+*D*	+100	0	0	0	0	0	0	+4.35	+4.00
C−*D*	0	+20.0	+14.3	0	0	+5.88	+5.26	0	0



Figs. 5 and 6. Lower part of speed-torque curve of winding A at 100 volts (left); and speed-torque curve of winding B at 110 volts (right)



Figs. 7 and 8. Lower part of speed-torque curve of winding C at 110 volts (left); and speed-torque curve of winding D at 110 volts (right)



Figs. 9, 10 and 11. Speed-torque curves of windings A + B at 110 volts (left), windings C + D at 110 volts (middle), and windings A+B+C+D at 230 volts (right)

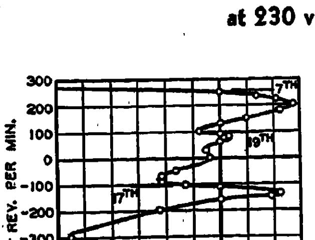


Fig. 12. Section of speed-torque curve of windings C—D at 115 volts

in reactance due to one winding being deeper in the slots. As may be noted, the generator torque of the 13th harmonic is great enough to cause the resultant torque to become negative and the motor operates at the low speed of the 13th harmonic and will not rise to full speed by itself. It will be noted in Fig. 7 for winding *C* that the 5th and 11th harmonics cause stable operation in opposite direction to the fundamental field.

It was also possible to secure other wave shapes by connecting the windings in different series combinations. Figs. 9, 10, and 11 further illustrate the effect of such recombination on the wave form. In these cases, certain of the harmonics cancel each other. Another method of illustrating the fact that the harmonic torques are present and are of considerable magnitude, is to place two windings in series with fundamental waves opposing and harmonic waves assisting. Fig. 12 shows the case of opposing windings *C* and *D*.

An attempt has been made in this article to bring out first, that the harmonics in the field form have a very definite effect on the speed-torque curves, and second, that the assumption of each harmonic acting separately, while not rigorously correct, is useful in determining the speed at which cusps are likely to occur.

Skewed Slots in Induction Motors

By
R. D. BALL
Associate A.I.E.E.
English Electric Co., Ltd.
Bradford, England

INDUCTION MOTOR slots are usually skewed to prevent "cogging" and noise on load, but indiscriminate skew irrespective of number of poles, especially when this number is large, leads to very large reduction of short circuit current and motor performance. The reduction of short circuit current is due not so much to increase of leakage reactance as to an unbalanced component of mutual flux.

In the following theory expressions are given for the ratio of short circuit current with skewed slots to short circuit current without skew, as a function of "dispersion coefficient" τ and skew angle.

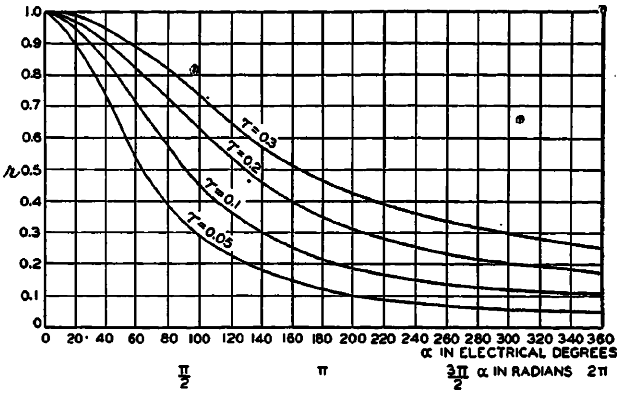


Fig. 13. Relation between short circuit currents, "dispersion coefficient" and skew angle

For the sake of simplicity, the motor is assumed to possess negligible primary and secondary resistance. The symbols used are as follows:

$\tau = \dfrac{X}{M} = \dfrac{\text{magnetizing current}}{\text{short circuit current without skew}}$ (approximately)

X = total leakage reactance

M = mutual reactance

f = skew factor = $\dfrac{2 \sin \dfrac{\alpha}{2}}{\alpha}$

α = skew angle = $\dfrac{\text{slot pitch skew}}{\text{total slots}}$ × pole pairs × 2π radians

V = applied voltage

I_1 = primary current

I_2 = secondary current referred to primary

$r = \dfrac{\text{short circuit current with skewed slots}}{\text{short circuit current without skewed slots}}$

If equal primary and secondary leakage reactance is assumed, we get the usual transformer equations

$$jI_1\left(1+\frac{\tau}{2}\right)M + jI_2Mf = V \tag{1}$$

$$jI_2\left(1+\frac{\tau}{2}\right)M + jI_1Mf = 0 \tag{2}$$

From eq. 2

$$I_2 = -\frac{I_1M}{M\left(1+\frac{\tau}{2}\right)}f = -\frac{I_1f}{\left(1+\frac{\tau}{2}\right)} \tag{3}$$

Substituting eq. 3 in eq. 1 we obtain

$$jI_1\left(1+\frac{\tau}{2}\right)M - jI_1\frac{M}{1+\frac{\tau}{2}}f^2 = V$$

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

$$I_1 = \frac{V}{jM\left[\left(1+\frac{\tau}{2}\right) - \frac{f^2}{1+\frac{\tau}{2}}\right]} \qquad (4)$$

Without skew, $\alpha = 0$, hence $f = 1$
Therefore

$$r = \frac{\dfrac{V}{jM\left[\left(1+\frac{\tau}{2}\right) - \frac{f^2}{1+\frac{\tau}{2}}\right]}}{\dfrac{V}{jM\left[\left(1+\frac{\tau}{2}\right) - \frac{1}{1+\frac{\tau}{2}}\right]}}$$

$$= \frac{\left(1+\frac{\tau}{2}\right)^2 - 1}{\left(1+\frac{\tau}{2}\right)^2 - f^2} \qquad (5)$$

From eq. 5 we can plot the ratio r as a function of τ and f. Curves are given in Fig. 13, which can be used as a guide when choosing the skew angle. It will be noticed that a small error, due to the various assumptions made for the sake of mathematical simplicity, is introduced for large values of τ at $\alpha = 360$ degrees, but skew of this order naturally is never met with in practise.

A Study of the Three-Circuit Transformer

THREE independent electrical circuits which are coupled together magnetically may be represented by an equivalent circuit developed from fundamental equations. In general, these transformers may be divided into two distinct types depending upon the relative directions of the mutual fluxes between the three windings. According to C. F. Estwick, (M'25) of the General Railway Signal Company, Rochester, N. Y., who discusses this type of transformer in a current A.I.E.E. paper, any arrangement of three coupled circuits will have the characteristics of either one or the other of the two types mentioned.

In the first type of transformer discussed by the author the coils in each circuit, or the cores on which they are mounted, are parallel to each other or arranged in the form of a Y. Under such conditions it is practically impossible to have a mutual flux threading through all three coils. In the second type the three coils are wound on one core or otherwise arranged on separate cores placed so that a path is provided for magnetic flux to interlink with the conductors in all three circuits. The author sets up equivalent circuits for both types of transformers, and for these derives equations which take into consideration the various mutual fluxes. To demonstrate the applicability of the formulas derived one simple typical problem is presented for each type of transformer.

Abstracted from "The Three-Circuit Transformer" by C. F. Estwick, (No. 31-69) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

Remote Reading of Watthour Meters

A scheme is described whereby watthour meter readings may be "observed" over regular subscribers' telephone circuits.

By
A. S. FITZGERALD
Member A.I.E.E.
Wynnewood
Pennsylvania

REMOTE READING of electric meters in residences is not feasible by any of the several telemetering schemes so far developed on account of the amount and nature of special apparatus required at the meters being read. A scheme worked out in the General Electric Laboratory is described here in which the bulk of the apparatus is concentrated at the power company's premises, a simple electromechanical device being the only apparatus installed at the meter itself.

In this proposal, connection between the power company's "observing" apparatus and the consumer's meter is made by means of telephone lines, the connection being made through the power company's connection with the telephone central exchange, thence to the consumer's residence over the telephone company's regular subscriber's circuit. A special mutual agreement would have to be reached, of course, to permit the necessary interconnection of power and communication equipment. Any system of remote

---

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

A beat-frequency audio generator with four tuning dials corresponding to the four dials of the watthour meter is installed at the power company's office (left). Attached to the meter (right) is a simple electromechanical vibrating device fitted with four rows of ten reeds each, one for each digit. This unit is actuated by an electromagnet which in turn is energized by the audio generator via the telephone line. Each reed resonates at a different frequency but all within the frequency range of the generator. To obtain a reading the observer signals the telephone central-office operator and gives her the number of the party whose meter is to be read. After the connection has been established (without ringing or otherwise disturbing the consumer) the observer switches on the audio generator to read the "thousands" dial. As the generator frequency is varied, the reeds of the "thousands" row vibrate into contact with the spindle separately and successively until one is found which makes contact with one of the ten segments mounted spirally on the spindle surface. This short circuits the electromagnet coil and causes a change in the signal to which the observer is listening. The position of the tuning dial then indicates directly the position of the "thousands" pointer. In like manner the readings of the other pointers are ascertained.

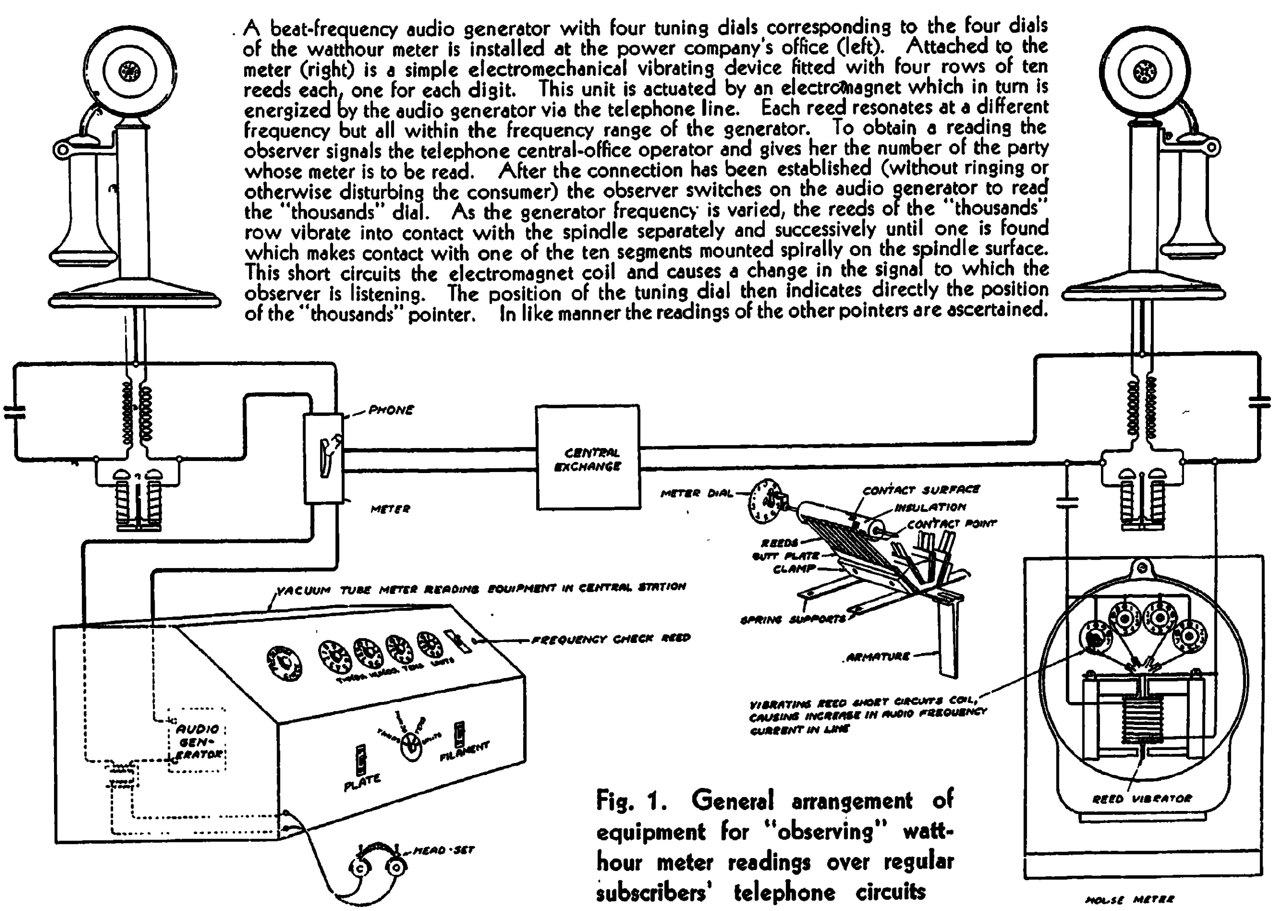


Fig. 1. General arrangement of equipment for "observing" watthour meter readings over regular subscribers' telephone circuits

reading quite obviously must justify itself from a cost standpoint. Average cost for reading a meter in a city district has been estimated at from 1.5 to 2.0 cents, and from 10 to 15 cents in a rural district. On the basis of these estimates the maximum justifiable investment for remote reading equipment is $4 for city and $30 for rural districts. An additional expense item would be involved in the use of the telephone company's lines. Also the fact that the plan postulates that each consumer is a telephone subscriber must be taken into consideration.

The general arrangement of equipment, together with the scheme of operation are indicated in Fig. 1, while in Fig. 2 may be seen a standard watthour meter rigged up for experimental purposes. The four tuning dials of the audio generator in the power company's office are arranged so as to indicate directly the positions of the four meter hands. Thus, after all four dials of the generator have been adjusted to "find" the positions of their respective meter hands, these tuning dials directly represent the watthour meter reading.

Several difficulties were experienced during the course of the experiments. One of the chief of these concerned the vacuum tube audio generator. Most of these difficulties were overcome, however, with the installation of a more stable and precise unit, and the provision of means for checking its accuracy. Variation in the frequency of response of the reeds due to wearing of the contact tips or temperature differences was found to be negligible. However, serious difficulties would be

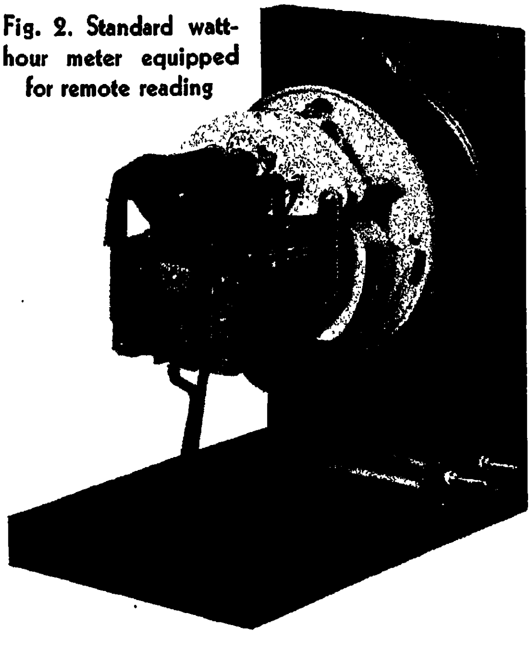


Fig. 2. Standard watthour meter equipped for remote reading

experienced in carrying out the scheme where party telephone lines are in use, or where machine switching exchanges are employed. Additional equipment no doubt would be required under these conditions.

Equipment and circuit arrangements described in the foregoing are mentioned merely as a suggestion of a future possibility. Engineering phases of the problem have been proved by extensive laboratory experiments to be capable of relatively simple solution, but of course the commercial application is quite another question and naturally would hinge principally upon the intercompany agreements that would be necessary before established communication channels could be put to such use.

Cable Temperatures at Variable Loading

Accurate methods, long available for calculating the temperatures in power cables during steady loads now can be supplemented by methods of calculating cable temperatures during fluctuating loads. Under favorable circumstances these give accuracies within 5 per cent. Further, the m thod is simple, and calculations can be made readily.

By
E. A. CHURCH
Associate A.I.E.E.

Edison Electric Illuminating Co. of Boston

MAXIMUM USE of the large investment in power cables can be made only if accurate information on the temperatures and loading limits of cables during variable loads is available. Although there are now fairly accurate methods for calculating the temperature rise when the load is steady, until recently no attempt was made to obtain even a moderately rigorous solution for the case of variable loading.

A point-by-point method of solution for variable loading based on the assumption that the temperature of the conductor rises exponentially with time was given in the JOURNAL of the A.I.E.E., October 1930, p. 855. This, however, is only approximately true and the theory presented below tends to show that the temperature curve rises faster at first, and then slower than the exponential law would allow, for example at 1 hr. after the load is applied.

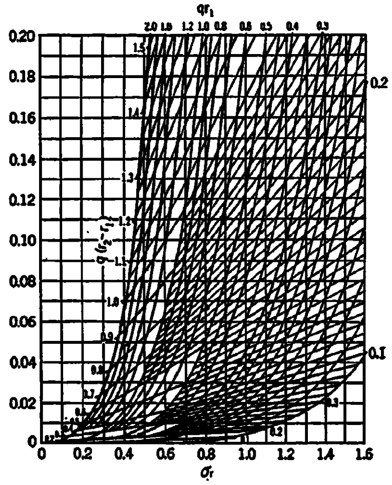


Fig. 1. Heat flow constant: $\sigma = i_2 k_1 - i_1 k_2$

$i_1 = I_0 \sqrt{j}\, q r_1 \qquad i_2 = I_0 \sqrt{j}\, q r_2$

$k_1 = K_0 \sqrt{j}\, q r_1 \qquad k_2 = K_0 \sqrt{j}\, q r_2$

By the use of Bessel functions, a rigorous solution of the problem of temperature rise from sheath surface to conductor is presented for single-conductor cables and three-conductor cables of shielded type H construction. Modifications of the cable constants allow the theory to be applied with reasonable accuracy to cables of standard belted construction. The heat flow cycle is resolved into harmonics and each harmonic solved separately for temperature at the conductor. Then the various harmonics of temperature are combined in their proper phase relation to obtain the temperature cycle. For purposes of assigning emergency ratings, a solution making use of the Fourier integral is derived for suddenly applied steady load.

SOLUTION FOR DAILY LOAD CYCLE

Derivation of the general equations for temperature in a single-conductor cable leads to the following simultaneous equations:

$$\frac{Q_0}{\pi} - j\,\frac{q_c^2 r_1^2 T_1}{S_c} = \frac{2}{S_i\,\sigma}\,(q_i r_1 \tau T_1 - T_2) \qquad (1)$$

$$\frac{D}{K}\,(T_2 - T_3) = \frac{2}{S_i\,\sigma}\,(T_1 - q_i r_2 \psi T_2) \qquad (2)$$

In the solution for three-conductor cable, eq. 1 remains the same, and eq. 2 is written as follows:

Based upon "Temperatures in Electric Power Cables Under Variable Loading" (No. 31-75) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

$$\frac{D}{3K}(T_2 - T_3) = \frac{2}{S_i \sigma}(T_1 - q_i r_2 \psi T_2) \qquad (3)$$

where

T_1 = vector temperature at surface of conductor
T_3 = vector temperature at surface of insulation
T_3 = vector temperature of the air at the surface of the sheath
Q_0 = vector heat flow per conductor, equal to the $I^2 R$ loss
Q_1 = vector heat flow per conductor at inside surface of the insulation
Q_2 = vector heat flow per conductor at outside surface of the insulation, or at outside surface of the sheath if sheath losses can be neglected as they are assumed to be in eqs. 2 and 3
r_1 = inside radius of the insulation
r_2 = outside radius of the insulation
D = diameter of the sheath
q_c = $\sqrt{\omega C_c \rho_c S_c}$
q_i = $\sqrt{\omega C_i \rho_i S_i}$
ω = 2π × frequency of vector heat flow
C_c = specific heat of the conductor material
C_i = specific heat of the insulation material
ρ_c = specific gravity of the conductor material
ρ_i = specific gravity of the insulation material

The symbols σ, τ, and ψ represent complex constants, analogous to the general circuit constants of a transmission line, which depend on the constants and configuration of the cable. For ease in computation, charts of σ, τ and ψ based on Bessel functions have been prepared and are illustrated in Figs. 1, 2, and 3.

In carrying out any particular calculation, the watt loss in the cable is plotted for the load cycle assumed. This curve then is analyzed by well-known methods for its principal harmonics. The solution for temperature is obtained for each harmonic of heat flow and the results combined in their proper phase relation to give the resultant temperature cycle.

If the cable is installed in a duct and only approximate solutions are required, the value of T_3, the temperature of the air at the surface of the sheath can be assumed constant at the maximum value obtained over a 24-hour load cycle. Usually when the cable is installed in an ordinary duct bank T_3 will vary from 20 to 30 per cent of the total variation in temperature at the conductor. If T_3 is considered constant, its value becomes zero in eqs. 2 and 3, merely adding to the steady state component of the total temperature at the conductor, which is computed by well-known methods. Then the value of T_1/Q_0 will be constant in both phase and magnitude for any given cable. Hence, tables of T_1/Q_0 for any given cable may be compiled for the principal harmonics. These may be combined in their proper phase relation to obtain a solution for any load cycle.

On account of the effect of adjacent cables and the uncertainty of the constants of the duct bank, the best method of obtaining the air temperature at the sheath surface is by means of a maximum-reading thermometer surrounded by a thin shield of heat insulating material. It is generally conceded that the temperature in the duct outside the lead sheath is nearly the same throughout the space between the sheath and the duct and can be considered so in the solution for steady heat flow. Since the air has a very low thermal capacity, its temperature will follow the variations in the lead sheath very closely in phase. Hence, if the maximum value of this air temperature throughout the load cycle considered can be obtained, it may be added directly to the maximum temperature rise between this air and the conductor to obtain the total rise. The error caused by these temperature components being out of phase will be small, since the total variation in the air temperature is only about one-quarter of the total.

SOLUTION FOR A STEADY LOAD SUDDENLY APPLIED

The solution for a steady load suddenly applied is as follows:

$$T_0 = \frac{2\,Q_0}{\pi} \int_0^\infty \delta_r \frac{1}{\omega} \sin \omega t \, d\omega \, . \qquad (4)$$

where

T_0 = the temperature of the conductor at any time t after the steady load is applied
δ_r = the real part of the expression

$$\delta = -j\left\{\frac{\gamma}{\pi q_c r_1}\right\} \times \left\{\frac{1}{\dfrac{q_i r_1 \tau}{S_i \sigma} - \dfrac{\eta}{S_i \sigma (S_i \sigma D + \eta q_i r_2 \psi)} - \dfrac{q_c r_1 \gamma}{S_c}}\right\}$$

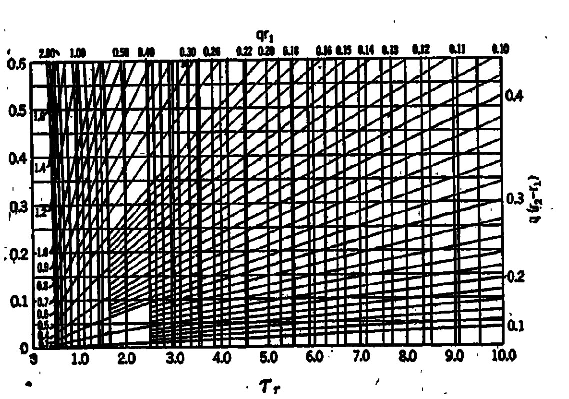


Fig. 2. Heat flow constant: $\tau = i_1' k_2 - i_2 k_1'$

$i_1' = \sqrt{j} I_0' \sqrt{j} q r_1 \quad k_2 = K_0 \sqrt{j} q r_2$
$k_1' = \sqrt{j} K_0' \sqrt{j} q r_1 \quad i_2 = I_0 \sqrt{j} q r_2$

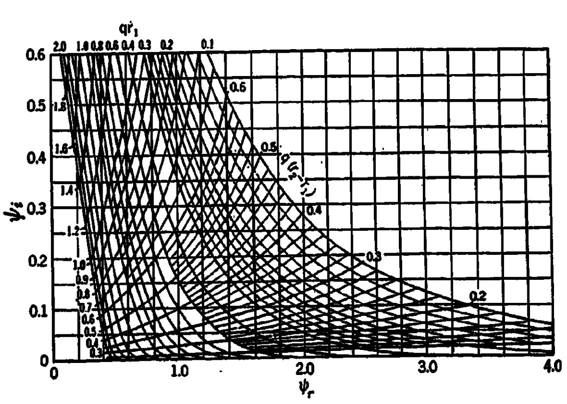


Fig. 3. Heat flow constant: $\psi = i_2' k_1 - i_1 k_2'$

$i_2' = \sqrt{j} I_0' \sqrt{j} q r_2 \quad k_1 = K_0 \sqrt{j} q r_1$
$k_2' = \sqrt{j} K_0' \sqrt{j} q r_2 \quad i_1 = I_0 \sqrt{j} q r_1$

where

$\gamma = j q_c \; r_i/2$ (approximately)

$\eta = 2\,K$ for a single-conductor cable in still air

$\eta = 6\,K$ for a three-conductor cable in still air

The expression

$$\frac{1}{\omega}\,\delta_r \sin \omega t \, d\omega$$

is much too complicated to integrate by formal means, but it may be integrated readily by graphical methods, as with a planimeter. The value of the function is plotted for different values of t and integrated with respect to ω. Integrating from 0 to ∞ offers no difficulty here since the function converges rapidly as the value of ω is increased.

STANDARD BELTED CABLE

The equation for obtaining the steady state temperature rise of the conductor above the outside surface of the insulation has been given by R. W. Atkinson (Cable Geometry and Calculation of Current Carrying Capacity, A.I.E.E. TRANS., Vol. XLII, 1923, p. 600) and by D. M. Simmons (Calculation of Electrical Problems of Transmission by Underground Cables, *Electric Journal*, August 1925, p. 366). This equation is as follows:

$$(T_1 - T_2) = \frac{Q_0\, S_i\, G}{2\,\pi} \tag{5}$$

where G is the geometric factor.

For the shielded cable, the geometric factor is given by D. M. Simmons (Calculation of Current Capacity of Type H Cable, *Electric Journal*, Feb. 1926, p. 59) as follows:

$$G = l\,n \frac{r_2}{r_1}\,.$$

For the cable under consideration, obtain values of G from the curves given in the first of the two articles by Simmons just referred to, and solve for an equivalent S_i. In average cables this equivalent S_i is about double the true value for the insulation under consideration. This value of S_i may be used in eqs. 1 and 3, to obtain an approximate solution which it has been found gives the result within 5 or 10 per cent of the true values as far as the variable component of temperature is concerned. The rigorous solution for standard cable which would involve much more labor would have no value as long as the cable constants cannot be obtained with any greater accuracy.

PROBABLE MAGNITUDE OF ERRORS

The change in resistance and dielectric loss with change of temperature for ordinary load cycles will not be over 5 or 6 per cent. If it is desired to take this into account a correction may be applied to the watt loss curve corresponding to the estimated temperature at that time. The value of temperature rise to be assumed in making this correction can be taken as half the ultimate temperature rise produced by the average watt loss over an hourly period. This is based on the fact that in average cables the temperature at the conductor reaches about half its ultimate temperature within an hour after a steady load is applied. The error introduced by change in resistance will be less than 0.5 per cent if this correction is made.

For sector conductors, the heat flow will be more concentrated around the regions of smaller radius but the error in neglecting the effect of sector shape will not be over 1 or 2 per cent.

Large conductors show considerable proximity effect when three conductors are concentrated in the small area inside the cable sheath. When three-phase current is flowing the current tends to crowd to the inside of the cable sheath. However, under the assumed condition of uniform current distribution the total variation in temperature through the conductor is only 1 deg. for ordinary load cycles. The smallness of this variation is due to the high heat conductivity of the copper. Hence, if the proper equivalent a-c. resistance is used for the cable in question, the error in temperature due to unsymmetrical current distribution will not be over 1 per cent. Of course this assumes that all the losses, excluding dielectric losses, are in the conductor. There are undoubtedly some losses in the sheath even in three-conductor cables, especially where large conductors are close to the sheath as they are in shielded cables. Not knowing definitely where all these losses are located, the conservative method would be to assume them all in the conductor.

Neglecting the temperature drop in the copper foil around the conductors in shielded cables introduces about 8 to 9 per cent error in the steady state solution. A similar error will be introduced in the solution for variable load. This error will be minimized in the total temperature rise if the steady state component of the temperature cycle is computed taking this drop in the foil into account as indicated in the second article by Simmons, previously referred to. Neglecting the heat storage in the lead sheath partially compensates for this error.

The over-all error in the method is thus not over 5 per cent and is probably much less if the watt loss curve is corrected for temperature. It is doubtful if the value of the insulation heat conductivity is known within 5 per cent plus or minus, so that it is useless to expend the labor necessary in obtaining greater refinement.

By means of computations based on this theory the temperature curve for any cable and load cycle may be calculated readily without excessive labor and with accuracies well within the accuracy of the cable constants. The effects of day-to-day changes in load cycle die out in a few hours so the theory can be applied to any day of the week with little effect from the previous day's cycle. Short-time overload ratings of any duration may be added to any initial loading with confidence that the calculated temperature rise will not be exceeded.

Progress is the Way Out of Depression

Intelligent self-interest, individually applied with sincerity of purpose toward the solution of every-day problems, is recommended as the most efficacious way out of present economic troubles. This is the fifth article of The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
ARTHUR W. BERESFORD Secy., Natl. Elec. Mfrs. Association

THE CURRENT economic depression cannot be ascribed to any single cause, nor will a panacea be found in righting any single wrong. Moreover, there is little of value at the moment in attempting to isolate and correct the major causes. They will emerge gradually from the present chaos as time provides a perspective; their evaluation will furnish the basis for long-time planning which should operate against recurrence. But this long-time planning, valuable as it would be, cannot be done now. The problem is too vast, the factors too many, and their inter-relations too complicated to be grasped and ordered by the human mind. So, in place of the co-ordinated effort which would be the outcome of a master plan, we must use what we have.

What have we? We have millions of men and women, each one of whom comprehends clearly some small part of the whole. If each of them spends each day in doing his individual best toward moving in the direction each knows to be right those things that each one understands, there is no fear of the outcome. There may be a wastage which would be absent in a master plan, but the whole will move forward surely and before a master plan, however imperfect, could be evolved.

This is an old and simple doctrine. Anyone can think it, and unfortunately it carries none of the exaltation that comes from the spectacular. But it is sound doctrine, and in the measure in which it is practised will be found the rate at which we will progress.

Human progress is not the result of the effort of the outstanding few, be they statesmen, industrialists, scientists, engineers, or inventors. It is the cumulative effect of the daily effort of the millions. The leaders but guide or accelerate it. The summation of the thousands of millions of small things is greater than the greatest large thing that the human mind can grasp. The combined effort of millions of average human beings will outweigh the most daring conception of the greatest vision the world ever has known. And these millions will put forth that effort, not as a result of ordered consideration, nor even by reason of instinctive realization, and least of all from any altruistic motive, but purely and wholly from self-interest. The efficiency of the process will lie in the degree in which that self-interest is intelligent; the hope of efficiency rises from the fact that there is growing comprehension that self-interest must be intelligent.

The average manufacturer perceives today that his interest and that of his workmen is a common one. He does not prosper if they do not. This long has been the conviction of the few, but it required the current condition to bring this realization home to the many. And again will be demonstrated the workings of this simple doctrine of mass effect. Eighteen months have increased the *quantity* of understanding more than the preceding eighteen years. Further, there has been made manifest the need for balance in the economic forces which make up our involved civilization. A force is constructive or destructive in the degree that it is or is not controlled. Production, whether of foodstuffs, of raw materials, or of finished goods, is constructive if balanced against consumption. It is destructive if unbalanced and guided only by unintelligent and immediate self-interest. Surely the past months have brought to the many a realization of this simple fact. From this realization there will as surely follow provision for assuring that balance.

The means are not yet clear, and a period of trial and error is to be expected before an approximate solution is found. However, the mere fact that stabilization of employment is economically dependent on controlled production, and consumption dependent on stabilized employment, will unite all elements in a common demand for that solution. This would not have been possible five years ago; but the thinking forced on the many in the past two years has brought an understanding of fundamentals which makes it not merely possible, but certain, and for the near future.

The present conditions are difficult to contemplate with mental serenity and undisturbed confidence, but they carry more of ultimate value than the prosperous years that preceded them. The growth of understanding by the many will form the foundation for a new and greater progress, for a civilization such as the world has not yet known. In this progress the engineer and the engineering method of basing procedure on determined fact will have a major part. The saying that "through adversity we progress" again will demonstrate its truth.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

Extinguishing the Short A-C. Arc

Three articles are presented herewith, following a common introduction, all on the same general subject, namely, the extinction of the short a-c. arc at low voltages in air. The importance of this subject is emphasized by the increasing use of the low-voltage a-c. distribution network and of a variety of equipments for interrupting circuits in air.

SHORT ARCS are employed in all circuit interrupters operating in a-c. circuits of less than 150 volts, and also are made use of in the deion air circuit breaker, where many short arcs are placed in series for operation at high voltages. Of equal importance is the behavior of an arc during a short circuit in low-voltage a-c. cables. The low-voltage network which is finding such great popularity as a system of distribution in metropolitan areas is dependent upon the capacity which it enjoys for self-clearing of faults without interruption of the power supply. This system insures that at any point of fault there will be sufficient current to melt apart any contacting metallic conductors and start an arc, and the low voltage which has been used on most networks insures that the arc will be extinguished quickly at a normal zero of current.

The first article, that by Attwood, Dow and Krausnick, presents in considerable detail the results of a very comprehensive group of tests on the reignition of a-c. arcs in air for different rates of build-up of the circuit voltage across the arc space. Throughout their tests the arc was produced by a current of 25 amperes at 660 volts, 60 cycles between flat copper electrodes placed ¾ in. apart in air. Although a strict interpretation of their results must be confined to low-current arcs, the very large number of oscillograms which they carefully have taken, studied and presented, throw considerable light on exactly what happens during the extremely short period when the arc current is at zero.

The second article, by Browne, presents the results of a group of experiments on the more common types of stationary arcs with molten electrodes, for the purpose of determining the influence upon the arc characteristics of such parameters as electrode material, current strength, and length of arc. The third article, by Slepian and Strom, is concerned principally with the effect which cable insulation has on the extinguishing of faults in low-voltage a-c. networks, due to the deionizing action of gas blasts formed by the decomposing insulation.

The fundamental theory upon which all three of these papers are based is identical. The continuance of the a-c. arc is believed to depend upon repeated reignition for each new half cycle after a current zero. The extinction of the arc has been shown to depend upon the outcome of "a kind of race" between two opposing processes taking place within a very short period after the current reaches zero. The first is the building up of voltage across the arc space tending to cause the arc to reignite, and the second is the diminishing of the conductivity of the arc space, or the increasing of its dielectric strength, tending to prevent the arc from restarting. The first depends upon circuit constants and upon circuit conditions existing at the current zero, and so theoretically can be calculated according to well-known principles, although this may be rather difficult if the circuit is not sufficiently simple. The second process, and the one with which these articles are most concerned, depends upon the characteristics of the arc itself. These are exceedingly complex and as yet understood to only a very limited extent. This building up of dielectric strength depends upon conditions internal to the arc space, such as the nature and geometric arrangement of electrodes, the nature of the gas, presence of magnetic fields, and gas blasts.

According to the modern theory of conduction in gases, the rapid recovery of dielectric strength by an arc space immediately following a current zero must be due to the disappearance of the ions which are required for the conduction of the arc current. Ions disappear from the arc space by direct recombination in the arc space itself; discharge to the electrodes; recombination on surrounding walls or in surrounding cooler gases; recombination in cooler gases mixed turbulently into the arc space by gas blasts; and formation of an almost completely deionized layer adjacent to the cathode by the action of the ions of the growing impressed electric field. In short arcs, discharge to the electrodes appears to be most important, and in longer arcs, recombination on surrounding walls and gases. The importance of the gas blast in practical devices only recently has begun to be appreciated.

Although the theory upon which all three of these articles are based is identical, the terminology varies somewhat. Figs. 2 and 8 of the first article and Fig. 6 and 12 of the other two articles, all represent the increasing dielectric strength of the arc space as a function of time. This increasing dielectric strength is referred to by Attwood, Dow and Krausnick as the "reignition-time locus," while Browne does not coin any special phrase to designate it. Slepian and Strom refer to this quality as the "arc reignition characteristic." The latter also refer to the tendency of the circuit to build up voltage across the arc space as the "circuit reignition characteristic."

The conclusions presented by these authors regarding the factors aiding arc extinction are most interesting, and in some cases striking. In general, they are in agreement, although the first two articles differ somewhat on the effect which length of arc has on the recovery of dielectric strength by the arc space; and the first article also indicates that the "reignition-time locus" should be represented as an area rather than as a curve. Whether or not these apparent discrepancies result from the fact that the first article considers arcs of relatively low current values, 25 amperes, while the second reaches into currents of a few thousand amperes, may possibly be explained by the further tests on short arcs which doubtless will be made in different laboratories.

I—Oscillograph Tests on Low-Current Arcs

By
S. S. ATTWOOD
Member A. I. E. E.
University of Michigan
Ann Arbor, Mich.

W. C. DOW
Associate A. I. E. E.
University of Michigan
Ann Arbor, Mich.

W. KRAUSNICK
Member A. I. E. E.
Ohio Northern University
Ada, Ohio

REIGNITION OF A-C. ARCS being dependent upon the arc-voltage relations during current zero, a study based on some 200 cathode-ray oscillograms has been made of the voltage and current relationships near the cyclic current zero in arcs between metallic electrodes.

For experimental purposes a 25-ampere 660-volt 60-cycle arc between flat copper electrodes spaced ¾ in. apart in air was utilized. The circuit used (see Fig. 1) consisted of a transformer of voltage e_s connected to the arc through a reactor L, with its small (but not negligible) distributed capacity C_L. The voltage e_a of necessity was measured by a cathode-ray oscillograph because of the extremely rapid variations. Time relations existing between the supply voltage e_s, the arc voltage e_a, and the arc current i_a are shown also in Fig. 1. During approximately 95 per cent of each half cycle the arc current is a sine wave lagging practically 90 deg. behind the supply voltage, while the arc voltage remains constant. It is upon the remaining 5 per cent of the half cycle that the major part of this investigation has been concentrated.

Eventually the arc current reduces sinusoidally to a small value I_1 (order of 0.1 ampere) at which value it suddenly fails, falling sharply to zero, where it remains until the arc again is made with current in the opposite sense. During this short period the supply voltage is practically constant ($e_s = E$).

The current i_L in the inductance cannot cease flowing instantaneously and therefore surges into the distributed capacity. During the period of current zero (from 0 to t_1) the voltage e_a may be computed by the usual circuit equations, which are shown also in Fig. 1. In the circuit used, L was 0.066 henry and C_L was 440 $\mu\mu$f.; with these values a cosine voltage having a frequency of 29,400 cycles per sec. is set up across the arc terminals.

At time t_1 when the electrode voltage has reached a value of perhaps 400 volts in the positive direction, the arc space breaks down and the voltage drops rapidly to the glow value of 350 volts, remaining constant for a period varying from an extremely brief interval to several hundred microseconds. During the glow period (t_1 to t_2) the arc current rises slowly. At time t_2 when the current through the inductance has risen to a value sufficient to maintain an arc, the electrode voltage drops sharply from the 350-volt glow value to approximately 100 volts for the arc proper; the arc current then resumes its sinusoidal character. Particular attention is called to the negative dip in the electrode voltage. This dip is due entirely to failure of the arc current at some definite value prior to the time when it would become zero had it continued along its sinusoidal variation.

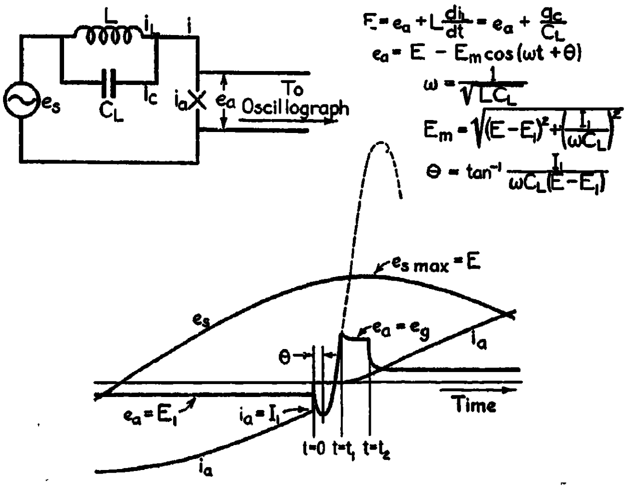

L
i_L
i
e_s
C_L
i_c
i_a
e_a
To Oscillograph
$E = e_a + L\frac{di_L}{dt} = e_a + \frac{q_c}{C_L}$
$e_a = E - E_m \cos(\omega t + \theta)$
$\omega = \frac{1}{\sqrt{LC_L}}$
$E_m = \sqrt{(E-E_1)^2 + \left(\frac{I_1}{\omega C_L}\right)^2}$
$\theta = \tan^{-1}\frac{I_1}{\omega C_L(E-E_1)}$
$e_{s\,max} = E$
e_s
$e_a = e_g$
i_a
θ
$e_a = E_1$
$i_a = I_1$
Time
$t=0$
$t=t_1$
$t=t_2$
i_a

Fig. 1. Current-voltage-time relations for the unshunted a-c. arc. At the upper left may be seen a schematic diagram of the test set-up

---

From "Reignition of Metallic A-C. Arcs in Air," (No. 31-33) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

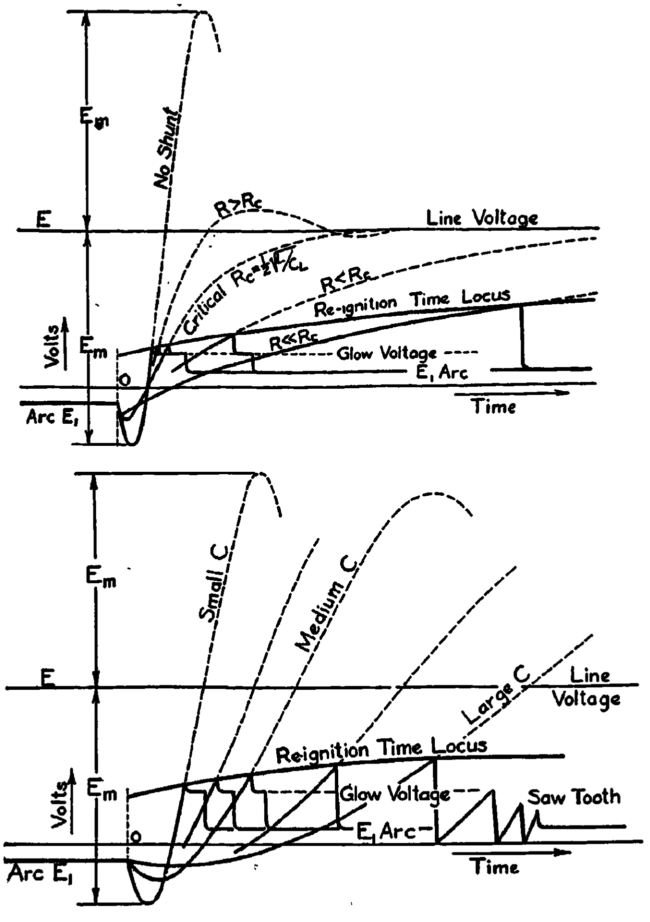


Fig. 2. Effects of resistance (above) and capacity (below) upon arc reignition time

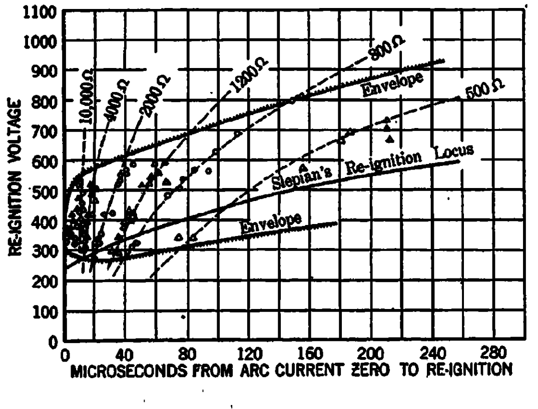


Fig. 3. Actual measurements of reignition voltage-time relations for various arc shunt resistances

If the arc electrodes are resistance-shunted, the circuit equations show that during the zero-current period, the rise of voltage across the electrodes will be slowed down materially. With more time available for deionization the electrode voltage must rise to a higher value in order to break down the arc region. The effect of varying this shunt resistance may be seen in Fig. 2. The line drawn through the breakdown values may be called the *reignition-time locus*. This locus shows the rapidity with which the deionization process in the arc space proceeds during the zero-current period.

For an arc shunted by resistance greater than the critical resistance, the electrode voltage e_a may be computed from equation (1), which represents a damped sine wave.

$$e_a = E - e^{-\frac{1}{2RC_L}t}\Bigl[(E - E_1)\cos\omega t + \frac{1}{\omega C_L}\Bigl(-I_1 + \frac{E - E_1}{2R}\sin\omega t\Bigr] \qquad (1)$$

where $\omega = \sqrt{\frac{1}{LC_L} - \frac{1}{4R^2C_L^2}}$

$$R > \frac{1}{2}\sqrt{\frac{L}{C_L}}$$

For values of resistance less than the critical amount,

$$e_a = E - e^{-\frac{1}{2RC_L}t}\Bigl[(E - E_1)\cosh\beta t + \frac{-I_1 + \frac{E - E_1}{2R}}{\beta C_L}\sinh\beta t\Bigr] \qquad (2)$$

where $\beta = \sqrt{\frac{1}{4R^2C_L^2} - \frac{1}{LC_L}}$

$$R < \frac{1}{2}\sqrt{\frac{L}{C_L}}$$

For still smaller values of resistance equation (2) reduces to the simpler form of equation (3)

$$e_a = E - e^{-\frac{Rt}{L}}[E - (E_1 + I_1R)] \qquad (3)$$

For resistance shunts greater than the critical value it may be noted that the arc-voltage rise takes the form of a damped sine wave. For resistances smaller than the critical value, the voltage-rise curve is a hyperbolic function of the circuit constants and time, and is asymptotic to the line voltage E. The critical resistance proved to be 6,125 ohms for the circuit constants used in this study.

Equations shown in Fig. 1 apply also to the voltage and current relations in a capacity shunted arc if the shunt capacity C is used in place of the now negligible distributed capacity C_L. Inasmuch as C is usually much greater than C_L the cosine curves of electrode voltage rise are much slower than in the non-shunted arc. This point is illustrated in the lower part of Fig. 2.

In Fig. 3 are plotted the actual reignition voltage-time points as obtained from oscillograms for a number of different resistance shunts across the arc. The dashed curves indicate the voltage rise across the electrodes. Particularly worthy of note is that reignition may occur anywhere along the voltage-rise curve between the limits set by the upper and lower parts of the envelope. There is no single value of voltage at which reignition takes place, but a general upward trend with time is shown by the reignition envelope. A set of tests using capacity shunts led to the development of an envelope which is identical with the envelope shown for the resistance shunts.

Significance of the three regions into which the envelope divides Fig. 3 is perhaps most clearly explained as follows: when the rising electrode voltage is below the lower branch of the envelope, reignition cannot take place; inside the envelope region reignition may take place, but it invariably occurs by the time the upper envelope is reached. For a low-resistance shunt such as the 500-ohm case shown in Fig. 3 the electrode voltage may rise to the line voltage without reignition taking place. This has been observed frequently.

By using another method, Slepian (*Extinction of a Long A-C. Arc*, A. I. E. E. TRANS., Vol. 49, p. 421) obtained previously a reignition locus which is drawn on Fig. 3 for the sake of comparison. It is believed that his curve would coincide with the lower branch of the envelope if test conditions were identical.

Efforts to locate the cause of the variability of restriking voltage so far have been fruitless; it may be due, however, to the presence of impurities in the surfaces of the electrodes over which the arc moves, though ever so slowly.

In Fig. 4 are shown four cathode-ray oscillograms of the electrode voltage during the current zero period, each oscillogram showing a number of curves taken at least 20 cycles apart. These illustrate the changes occurring when the arc shunt resistance is varied. With a 10,000-ohm shunt, the cosine voltage wave is much in evidence; with resistances below the critical value (6,125 ohms) the hyperbolic curve may be observed. The 1,200-ohm case shows a rapidly rising voltage with reignition occurring at a practically constant value, whereas in the 4,000-ohm case the voltage rise is much slower with a decided variability in the reignition values. With 0.1-μ f. shunt a cosine voltage rise may be seen with a somewhat variable reignition voltage. The "saw-tooth" voltage peculiar to a capacity shunted arc is caused by the alternate charge and discharge of the shunting condenser, and hence occurs only with relatively large values of shunt capacity.

In the 10,000-ohm case it may be noted that two types of negative dip may occur. A peaked negative dip indicates that the arc current failed at a slightly larger value than for the curved negative dip; the negative voltage then rose to a value sufficient to cause glowing before the real current zero period was reached.

Application of this material to the action of a circuit breaker as it opens, drawing longer and longer arcs for each succeeding half cycle, is illustrated in Fig. 5. Three electrode-voltage curves and three expected reignition loci are plotted for three successive half cycles. Because the electrode voltage increases with increasing arc length, causing any given value of recovery voltage to occur at longer periods of time from the instant of arc failure, curves of this voltage start at different negative values.

The beginning points of the arc reignition curves are drawn higher for each succeeding half cycle because the greater electrode spacing should require a somewhat greater short-time value of breakdown voltage. The slopes of the arc reignition curves are made steeper for each succeeding half cycle because deionization should be expected to take place more rapidly with long than with short arcs. The crossing of curves 1, and again of curves 2, indicates successive half-cycle reignitions where the two curves meet. The fact that curves 3 do not intersect indicates that deionization has taken place with such rapidity that the voltage-rise curve never will meet the reignition curve and consequently, reignition no longer will take place.

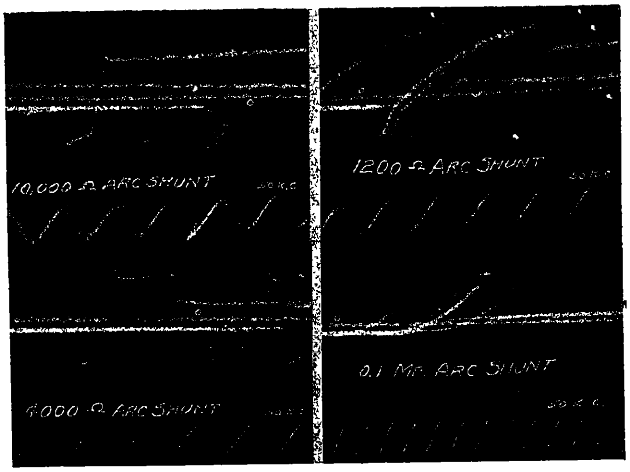


Fig. 4. Arc-voltage oscillograms with different arc shunts. (Critical resistance, 6,125 ohms)

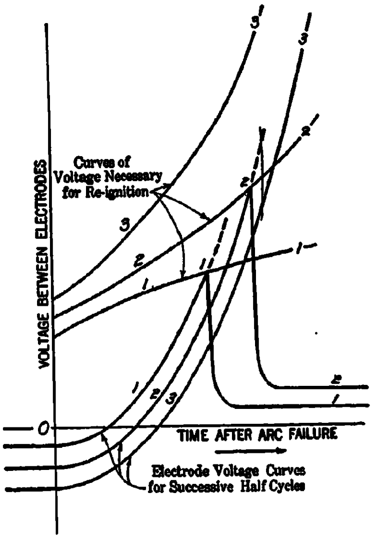

VOLTAGE BETWEEN ELECTRODES
Curves of Voltage Necessary for Re-ignition
TIME AFTER ARC FAILURE
Electrode Voltage Curves for Successive Half Cycles
0
1
2
3
1
2
3

Fig. 5. Expected reignition voltage-time relations for capacity arc shunts with increasing electrode spacing, simulating the arc conditions which exist when a circuit breaker opens

It is thought that loads on a line located near a circuit breaker which opens will operate upon the breaker in much the same manner as the shunt resistances discussed previously, tending to cause a delay in the rise of electrode voltage toward reignition, with a consequent lessening of the expected severity of circuit-breaker duty. It should be emphasized, however, that Fig. 5 illustrates qualitative action only. Care should be taken not to generalize too far into high-voltage or large current situations from the results here described.

II—Various Factors Aid Extinction of Arcs

By
T. E. BROWNE, JR. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

EXPERIMENTS to determine the influence of such parameters as electrode material, current strength, and arc length on the characteristics of the more common type of stationary arcs with molten electrodes, have given results not previously expected. Simplified calculations made by Slepian a few years ago based on the theory that ions are lost from the arc space only by direct ion recombination, predicted a manner of recovery of dielectric strength substantially the same as that actually revealed by experiments made on cold electrode arcs at about the same time. The rate of recovery of voltage across the arc space following a current zero was controlled by shunting the arc with resistance, and the maximum allowable rate of rise of voltage was determined from the maximum value of shunting resistance at which the arc would just be extinguished after one-half cycle.

In general, the experiments recently completed show that the manner of dielectric recovery following a current zero of short, stationary a-c. arcs with molten electrodes conforms to the predictions of Slepian's theory and is similar to the recovery of rapidly moving cold electrode arcs previously investigated. That is, for electrodes whose boiling temperatures are below the temperature required for appreciable thermionic emission, the ability to withstand 100 volts or more was recovered within a few microseconds after a current zero, and further dielectric strength was regained at a very much lower rate. This is shown by the curves of Fig. 6.

As predicted, the initial very rapidly recovered dielectric strength was found to depend solely on the electrode material and gas medium, and not at all on any other conditions within the limits investigated. The further more slowly recovered dielectric strength did not, however, prove to be independent of such conditions as arc length and current magnitude, as Slepian's approximate theory predicts that it should. This simply indicates that factors neglected in the simplified theory, such as diffusion of ions to the electrodes and to the surrounding air, the electric field, and temperature variations, are not actually negligible.

EFFECT OF ARC LENGTH

The effect of length of the arc on recovered dielectric strength was found to depend on the electrode material used. In the first series of tests made with brass electrodes, the effect of arc length was very striking and at first sight seemed paradoxical. As shown in Fig. 6, the dielectric recovery of a 0.158-cm. arc was considerably more rapid than the recovery of an arc of twice that length under otherwise similar conditions, indicating that the shorter arc is easier to extinguish than the longer. This effect is shown in a still more striking manner by plotting the initial slopes of critical applied voltage curves, like those shown dotted in Fig. 6, against arc length. This has been done in Fig. 7 for extinction at 450 volts, and shows that the effect extends up to five cm. or more, but is most pronounced at lengths of less than one cm. A similar but still more pronounced effect was observed with metals of lower boiling point than that of brass. With electrodes of the higher boiling metals, however, such as copper, iron, and tungsten, the effect was very much less and reversed its direction at the shorter lengths. This is illustrated by Fig. 8, which is the curve of Fig. 7 for brass, redrawn to a different scale and compared with similar curves for mercury, zinc, copper, iron, and tungsten-electrode arcs. The curves for copper and

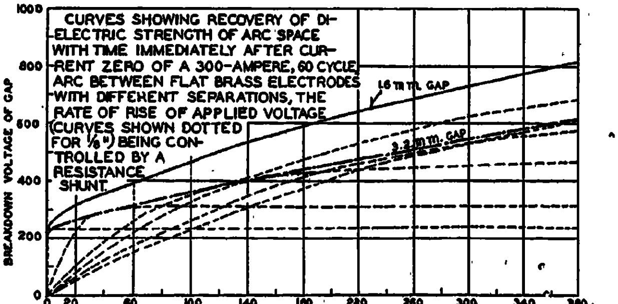


Fig. 6. Rate of recovery of dielectric strength of arc space immediately following a current zero

---

From "Extinction of Short A-C. Arcs," (No. 31-90) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1981.

iron are seen to coincide practically with that for brass near five mm. and above and to exhibit the same falling characteristic above about four mm.; but below this length, instead of rising rapidly with diminishing length as with the lower boiling metals, they fall off again; the curve for iron rapidly approaching zero and the curve for copper falling and then apparently tending again to turn upward at the shortest lengths investigated. With the very refractory metal tungsten, the curve is much lower even than with copper and iron, but still appears to reach a maximum at some arc length less than one cm. and to fall off with increasing length above that.

EFFECT OF ELECTRODE MATERIAL

As already shown, the behavior of a short a-c. arc depends very largely on the material of the electrodes. Fig. 9 shows the results of a series of experiments on 300-ampere, 60-cycle, 450-volt arcs, 0.079-cm., 0.158-cm., and 0.316-cm. long, using various metallic elements as electrodes. The critical initial rate of rise of voltage as measured by the critical shunting resistance for arc extinction is plotted in each case against the boiling point of the element. The interesting and surprising feature of this graph is the definite tendency for the points at each arc length to fall on intersecting straight lines. This approximately linear manner of variation with boiling point applies to all the metals for which results were obtained except mercury, which has values at about twice those required to fit the straight lines, and magnesium, aluminum, manganese, molybdenum, and tungsten (not shown), which either form stable refractory oxides or themselves boil at high enough temperatures for copious thermionic emission, thus preventing the immediate recovery of dielectric strength which characterizes the non-refractory metal arcs.

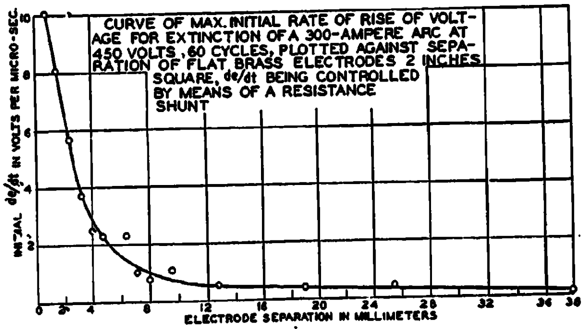
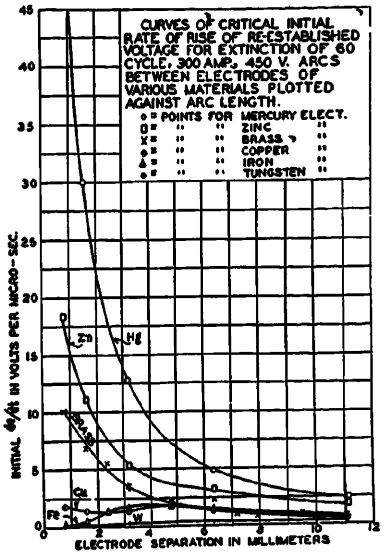


Fig. 7. **Initial slopes of critical applied voltage curves for extinction at 450 volts**

The performance of aluminum, copper, and brass-electrode arcs is shown comparatively in Fig. 10, in the form of curves of critical initial rate of rise of reestablished voltage plotted against the effective circuit voltage at which the values were obtained, other conditions than voltage remaining the same. Remembering that the ordinates of any one of these curves may be considered as a measure of the speed with which the arc space regains the ability to withstand voltages equal to the maxima of sine waves having the effective values given by the abscissas, it may be seen that 0.158-cm. arcs with aluminum electrodes require a very much longer time to recover ability to withstand a given voltage than do arcs of similar length between copper electrodes, and that 0.158-cm. copper-electrode arcs in turn recover dielectric strength very much more slowly than do 0.158-cm. brass-electrode arcs, other conditions being equal. The rapid rise of all of these curves at the lower voltages is attributed to the approach of the maximum voltage values to the minimum dielectric strength of the cathode-space charge sheath, which is recovered in practically zero time. This initially-recovered dielectric strength is approximately 160 volts

Fig. 8. **Effect of electrode separation on arc characteristics**



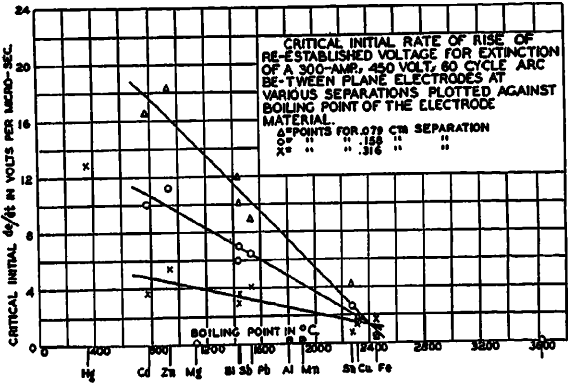


Fig. 9. **Effect of boiling point of electrode material on arc characteristics**

(maximum) for both copper and aluminum arcs, but is nearly 230 volts for brass-electrode arcs. Because of the scale used, the upper portions of the curves for copper and brass are not shown in this figure.

Effect of Current Magnitude

The simplified theory already referred to, predicted that the dielectric recovery of a short arc space should also be independent of magnitude of the arc current, but this prediction depended on the assumption that ionic diffusion to the surrounding air is negligible, which can be true only if the diameter of the arc is large in proportion to its length. Even for arcs only 0.158 cm. long, this condition is approached only at currents of more than a thousand amperes or so; therefore independence of current magnitude may be expected only with currents of this order. Fig. 11 shows this to be the case for a 0.158-cm. copper arc at 450 volts; current variations produce little change in the rate of dielectric recovery above 1,500 amperes, but below this value, decreasing the current causes a rapid increase in speed of dielectric recovery. Below about 150 amperes, the behavior of the arc becomes increasingly erratic so that definitely consistent values of a critical initial *d e/d t* were very difficult or quite impossible to determine. Tests made by F. C. Todd with the cathode-ray oscilloscope show that the restriking voltage of continually restriking arcs is extremely variable when the current is as low as 90 amperes.

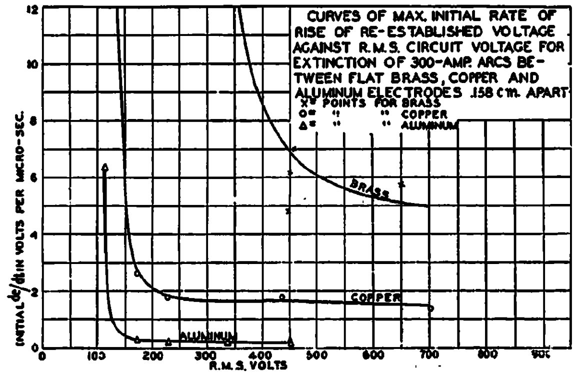


Fig. 10. Effect of circuit voltage on arc characteristics

Application to Engineering Practise

In view of the results herein presented, some suggestions may be made with regard to the construction of low-voltage circuit interrupting apparatus, where extinction of low-voltage a-c. arcs resulting from faults is important. Because of the marked superiority in short arcs of brass electrodes over copper or aluminum electrodes with regard to speed of recovery of dielectric strength at current zero, it would seem advisable to use brass for the contact-breaking parts of low-voltage switches working near their limit.

The suggestions in regard to the use of brass, copper and aluminum may apply with even more force when considering a material for conductors in secondary distribution networks than they do to switch construction. Thus it is suggested that the permissible operating voltage of such networks might be raised if brass conductors were used. These results, however, must be interpreted with caution when applying them to a problem having such varied practical aspects. Where the conductor material would also act as the electrode in case of a fault, it should be noted in Fig. 8 that the difference in favor of brass over copper applies only when the length of the arc is less than 5 mm. Consequently, if the arc would usually be longer than this, brass would probably be no more effective than copper or aluminum in aiding its extinction.

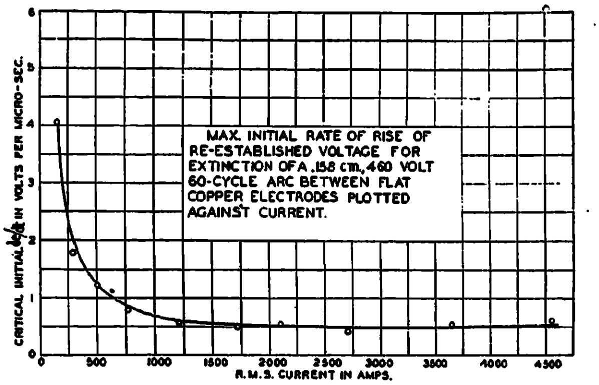


Fig. 11. Effect of current magnitude on arc characteristics

It may be noticed, also, that there is a discrepancy between practical experience with faults in secondary networks and the results given here, in that faults commonly are cleared on networks as high as 230 volts r. m. s. whereas in the laboratory, high-current copper-electrode arcs 0.158 cm. long could be easily maintained at as low as 113 volts. This may be due to less severe circuit conditions in the case of the practical network, caused by a fairly high power factor on short circuit and the presence of distributed capacitance of the cables and of shunting resistance in the form of connected lighting load, all of which tend to decrease the rate of recovery of voltage across the arc space at a current zero and so allow time for deionization of the arc and recovery of dielectric strength. Probably of more importance, however, is the deionizing action of gases resulting from burning of the cable insulation, the action of which is similar to that of gases from the decomposing oil in an oil circuit breaker.

III—Insulation Material Aids Extinction of Cable Arcs

By
J. SLEPIAN
Fellow A.I.E.E.

A. P. STROM
Associate A.I.E.E.

Both of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A CLOSE STUDY of the type of arcs occurring with faults in low-voltage a-c. networks and the method by which they are extinguished has brought out several striking conclusions. It has been found that short arcs between copper electrodes and not adjacent to insulation are inadequate to meet the fault-clearing requirements of low-voltage a-c. networks of more than 130 volts. Actual low-voltage networks of voltage higher than 130 depend for extinction of arcs upon the strongly deionizing action of gas blasts coming from decomposing adjacent insulation. As suggested by this result, it has been found also that the extinction of arcs in cables is strongly affected by the closeness of the insulation to the arc. Also, inorganic insulating materials giving off non-combustible gases have been found to be effective in aiding arc extinction, and of the various inorganic materials tried, boric acid was the best. Further, where organic insulation has been charred, it may be expected to lose its property of aiding arc extinction.

The Short Arc Without Gas Blast

Test curves of the recovered dielectric strength of the arc space, or "arc reignition characteristic," are shown in Fig. 12. It will be noted that up to a certain point there is an almost instantaneous recovery by the arc space of dielectric strength; after that the recovery of dielectric strength is much slower. Curves *A*, *B*, and *C* indicate that the immediately recovered dielectric strength is independent of the arc length. As shown by curve *C*, the slope was found to decrease with an increase of arc length. Curve *D*, however, indicates that for heavier currents there is an extremely low value of immediately recovered dielectric strength, and an extremely small slope of the characteristic for the first few hundred microseconds.

Earlier tests made by Kehoe indicate that the arc following a fault in an a-c. network cable will always be extinguished at 220 volts r. m. s. At 1,000 volts r. m. s., currents up to 500 amperes, and at 2,000 volts r. m. s., currents up to 100 amperes were also successfully interrupted by the arc. Although the tests at higher voltages were not conclusive, it appeared certain that at 220 volts the arc would be extinguished under all circuit conditions. These, and the results of other similar tests, are entirely compatible with the earlier data on arc reignition characteristics, such as curves *A*, *B*, and *C* of Fig. 12.

The more recent results indicated by curve *D*, and which should be more directly applicable to cable-fault arcs, are not compatible with these results. According to curve *D*, arcs with currents exceeding 1,200 amperes would not be extinguished with more than 125 volts or 130 volts r. m. s. in a low-power-factor circuit. We are then driven to the conclusion that in a-c. cable-fault arcs there must exist additional deionizing agents which are not active in ordinary short arcs between metal electrodes.

These additional deionizing agents must come from the insulation used in cables, and the authors believe that it comes from the intense blasts of gas directed to the arc from the adjacent decomposing insulation. This turbulent inpouring of fresh, relatively cool, un-ionized gas from the decomposing insulation may well cause the extinction of the arc in circuits of voltage higher than otherwise would be possible. Gases which are inflammable and under certain circumstances even may constitute an explosion hazard, are probably necessary in the functioning of low-voltage a-c. networks.

Tests on Arcs in Cables

Further substantiation of the important part insulation plays in the extinction of the arc, and an indication of the persistency of the arc when not subjected to the influence of insulation, was shown in a number of copper-to-copper short circuits made in short lengths of oil-impregnated paper-insulated cable. The cable used was 600-volt, three-conductor, 500,000-cir. mil lead-covered cable manufactured by the Habirshaw Cable Company. The arcs were started in several different ways, and were made in a 550-volt r. m. s. 60-cycle circuit in which the current was limited only by

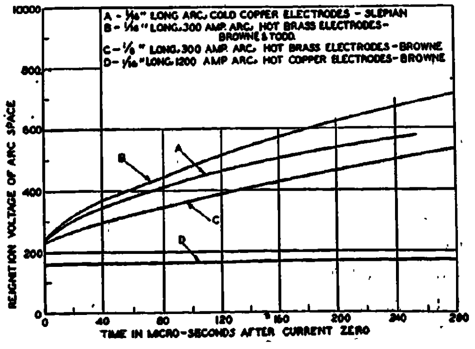


Fig. 12. Test curves of arc reignition characteristics

From "Arcs in Low-Voltage A-C. Networks," (No. 31-84) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

the reactive impedance of the transformers and cables. Currents varied from 3,000 to 10,000 amperes. In some of these tests the short circuit was made near the end of the cable opposite the power supply, and in others near the middle of the cable section, power being supplied from both ends to eliminate the strong magnetic blowout effect that is present with the first method of short-circuiting.

In general it was found that when the arc was closely bounded by insulation it would be extinguished in from one to fifteen half cycles. Occasionally, however, the arc would persist, and it was then found that placing resistance in shunt with the arc having a value as low as one ohm, had no influence on the extinction of the arc. In those tests where the insulation had been carefully cleaned away about 6 in. or more from the arc, the arc would then persist, and the arc voltage was about 350 volts, or three or four times as large as when the arc was bounded closely by insulation. This value is very much too high for an arc drawn in air and unexposed to any gas blasts. The only conclusion which can be reached is that it was caused by the decomposition of the insulation.

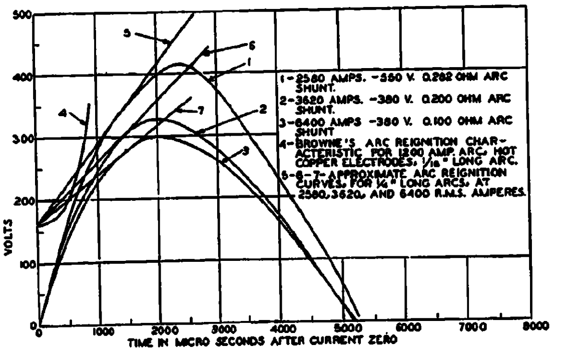


Fig. 13. Calculated circuit reignition characteristics are given in curves 1, 2, and 3

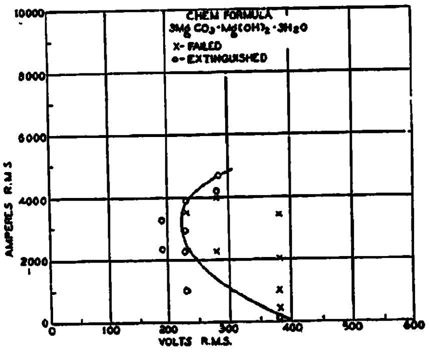


Fig. 14. Arc extinguishing properties of basic magnesium carbonate

Tests on Arcs Between Copper Plates

Definite confirmation of the importance of the decomposing insulation in extinguishing arcs, as well as quantitative results on both organic and inorganic insulation at heavy currents were obtained in a group of short-circuit tests made between a pair of copper plates. These were ¼ in. thick and 4 in. by 27 in. in area, spaced about ¼ in. apart. To keep the gas pressure between the plates low, ½-in. holes, spaced 1.41 in. between centers, were punched in the plates.

Tests were first made using only an air-gap between the plates, and values were determined for resistance which when in shunt with the arc would just cause it to go out. With these values the circuit reignition characteristics should be just tangent to the arc reignition characteristic. Three calculated "circuit reignition characteristics," or tendency of the circuit to build up voltage across the arc space are shown in Fig. 13, in which curve *D* from Fig. 12 is redrawn, and three probable arc reignition characteristics for the larger currents and spacing are indicated by curves from the 160-volt point on the voltage axis tangent to the various circuit reignition characteristics.

Arc potentials in these tests were found to vary from 40 to 100 volts, and it was shown decisively that the simple short arc between copper electrodes free from insulation is inadequate to meet the fault-clearing requirements of low-voltage a-c. networks.

Further tests were made with the same electrode arrangement but with oil-filled paper clamped between the copper plates, the fuse for starting the arc being passed through a ⅛-in. hole in the paper. At 550 volts the arc was extinguished for all values of current tried, up to 11,000 amperes. Similar results were obtained as the voltage was increased to 750, although at 1,150 volts the arc persisted. The arc potential was found to vary from 300 volts at low currents to 600 volts for high currents. Increasing the size of the hole to ⅜ in. caused the arc to persist at 550 volts, and the arc voltage was only about 200 volts. Tests in which the paper was impregnated with vaseline and with glycerine gave results practically the same as for the oiled paper, and the important part played by the insulation in the extinction of cable arcs was again affirmed.

Preliminary tests were then made using inorganic insulation which would give off incombustible gases such as water or carbon dioxide. The various materials in the form of powder were packed between the copper plates, and tests were then made as before. The arc was permitted to make as large a hole as it would in the closely packed, powdered material.

The results shown in Fig. 14 for basic magnesium carbonate are typical of the relation between the current and the voltage that can be interrupted by a given length of arc. As the current is increased from small values, the volts which can be interrupted, decrease, reach a minimum, and then increase again. This relation is rather to be expected if it is recalled that for very large currents the gas blast will be very intense, and that for very small currents the arc will be particularly sensitive to deionizing influences.

If, now, the voltage of the circuit is kept constant and only the circuit reignition characteristic is altered, similar results are obtained. Below a certain "speed" of circuit all currents are interrupted, whereas for higher "speeds" there will be an intermediate range of current for which the arc will persist.

This is illustrated in Fig. 15 which shows the results of tests using gypsum powder. All these tests were at 550 volts, with varying values of resistance shunting the arc to give different circuit reignition characteristics. For shunting resistances of less than 16 ohms, the arc interrupted all values of current; but for resistance greater than 16 ohms, there would be an intermediate range of current for which the arc would persist.

Because it so happens that most of the data for the different powders were obtained at 550 volts with varying resistance shunts, their efficacy may be compared by plotting in one figure several curves similar to that of Fig. 15. This has been done in Fig. 16. No curve is given for boric acid, as the arc interrupted all values of current even when unshunted, except for one test which did not repeat itself. The curve for gypsum is taken from Fig. 15, and consists of the boundary of the region of arc persistency. The other curves were obtained in a similar manner.

From all these data it is concluded that boric acid made the best arc-extinguishing powder, being as good as oiled paper over the range of these tests. The next, although considerably inferior, is gypsum. Then far inferior, though better than plain air, are the rest of the materials tried.

ARC-EXTINGUISHING SUBSTANCES

From these tests it will be noticed that some requirement other than the amount of gas generated for a given volume, or for a given energy input from the arc, must be taken into account. This other factor probably relates to the state of the surface of the bounding material just after the moment of arc extinction. Even though the arc will not reignite in the arc space itself, the surface of the bounding material must be able to withstand the voltage without breaking down. Organic insulation in general seems to meet this requirement, as the surface remains clean and is of good insulating quality.

Ammonium carbonate, however, melts below the temperature at which rapid decomposition takes place, and the surface of the material which is left after a half cycle of arcing undoubtedly consists of a molten film of the ammonium carbonate which is highly conducting. A considerable current flows in the molten surface film, and the resultant tearing of this film while carrying current will restart the arc. Although boric acid also has its melting point below that at which rapid decomposition takes place, the electric resistivity of the molten boric acid is very high. The current will be so small that the power will be insufficient to keep the boric acid film hot, and it will recongeal, thus permanently opening the circuit.

While organic insulation in general has the property of being left with a surface of good dielectric quality after exposure to the arc, it may not have this property after it has been subjected to a moderately high temperature, so that it is more or less charred before the arc begins to act upon it. Insulation which has become charred for any reason is ineffective in causing the extinction of the arc, because it has lost its more volatile constituents and because after exposure to the arc, the surface which is left is almost entirely free carbon and a good conductor while hot. With normal organic insulation, the rapid evolution of gas seems to scour away the surface and keep it clean of carbonaceous residues; but the charred insulation has lost this property.

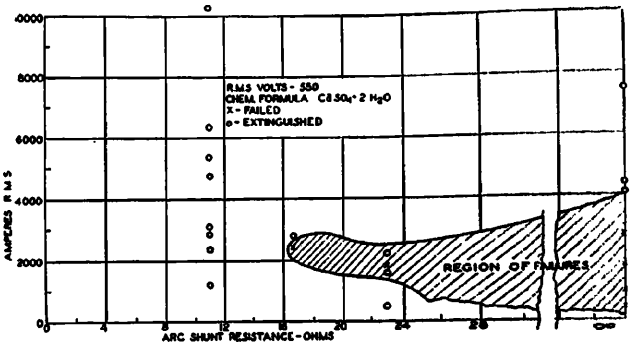


Fig. 15. Arc extinguishing properties of gypsum.

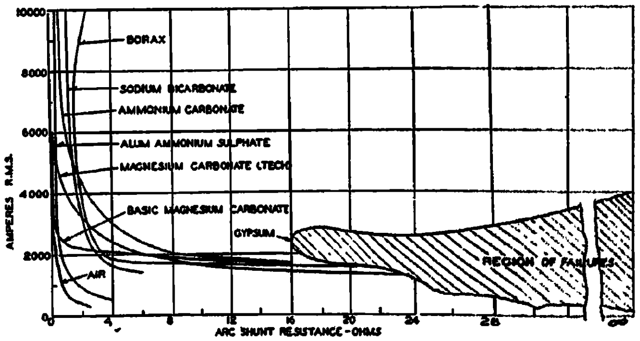


Fig. 16. Arc extinguishing properties of various powders

The Philadelphia A-C. Network System

By
H. S. DAVIS
Non-Member

W. R. ROSS
Associate A.I.E.E.

Both of the
Philadelphia (Pa.)
Electric Company

Because several of its basic features differ quite radically from other distribution networks, the engineering plan of the Philadelphia a-c. network is outlined and five years' operating experience is summarized.

THIS SYSTEM at present comprises 24 sectionalized primary loop feeders supplying three separate fused secondary networks areas totaling 1.26 sq. mi. The total 1930 peak load of the central business district of Philadelphia amounted to 72,820 kva., of which the a-c. network system carried 27,600 kva. and the remaining d-c. system 6,000 kw. The remaining 39,220 kva. is fed generally in large blocks at 2.3 or 13.2 kv. Supply for the whole area comes principally through four substations which in turn are fed from two steam-electric generating stations located about 1½ mi. away.

Each network area is fed by four primary loop feeders from each of two substations. These feeders are composed of three-conductor, 350,000-cir. mil paper-insulated lead-covered cable now operating at 2.3 kv., three-wire, two-phase, but designed for ultimate three-phase operation at 13.2 kv. Each feeder is routed through widely separated parts of its network area, interlaced with other feeders, and carried through several intersections to return finally to the substation of its origin. The several "unit-sections" of each primary loop are joined through 400-ampere 15-kv. subway-type oil circuit breakers subject to the control of the balanced pilot-wire protection scheme. For a standard 2-OCO-duty cycle at 2.3 kv. these breakers have a rupturing capacity of 30,000 amperes.

Network distribution transformers are all 100-kva. subway-type units of standard impedance. Most of them are constructed with the high-voltage winding in six sections, connected in parallel for present 2.3-kv. operation and permitting series connection for possible future operation at 13.2 kv. All of these transformers are installed in manholes usually four in a group together with one oil circuit breaker, two pilot cable junction boxes, and four low-voltage sectionalizing boxes. Barrier walls are not used in these manholes, but all (except control) cables are fireproofed.

The secondary a-c. network system is a grid of two-phase, five-wire 115-230-volt mains. This grid is fed from the primary loops through transformer banks placed at each main street intersection. To provide automatic isolation in cases of trouble the secondary mains and transformer leads are equipped with copper link fuses. These fuses are installed in five-way, single-polarity sectionalizing boxes to which the four secondary mains and the transformer leads are connected. Fuse capacities used are 1,250 amperes for mains and 1,500 amperes for transformer leads.

In the secondary network 350,000-cir. mil, 600-volt, paper-insulated, lead-covered cables are used. Single-conductor cables from the fused sectionalizing boxes may be spliced to single- or multiple-conductor mains. In many instances the three-conductor cables of the former d-c. network were used for one phase and two single-conductor cables installed to complete the system of two-phase mains. Present practise is to install single-conductor cable for the phase wires and a 2/0 bare neutral wire.

Both lighting and power loads are fed from the same set of secondary mains. No auto-transformers are required on the secondary network because the system conforms to accepted voltage standards for both light and power. Thus all parts of the system may be paralleled at will. It is of interest, too, to note that two-phase motors up to 40 hp. are taken on any part of the network, when well established, without requiring current-limiting devices for starting.

OPERATING EXPERIENCES

In general, five years' operating results with the Philadelphia network system have been satisfactory. Some of the more important operating experiences are outlined briefly in the following paragraphs.

1. In one case, trouble in a generating station cut off the power supply to a pair of substations feeding one of the network areas, dropping a 5,000-kva. load. Service was restored promptly, however, by resorting to the use of interstation tie lines. This enabled one of the dropped substations to pick up the whole area load during the emergency period.

2. In the second of two instances where system disturbances affected network areas, no service interruption occurred. In this case the 132-kv. transmission feeders to one of a pair of network-area substations were lost successively, dropping the entire area load of about 6,000 kva. on the second substation. This second substation thus carried for the emergency period all of its own load, the whole network-area load, and (through feedback) several important radial feeders from the first substation.

From "The Philadelphia A-C. Network System" (No. 31-56) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

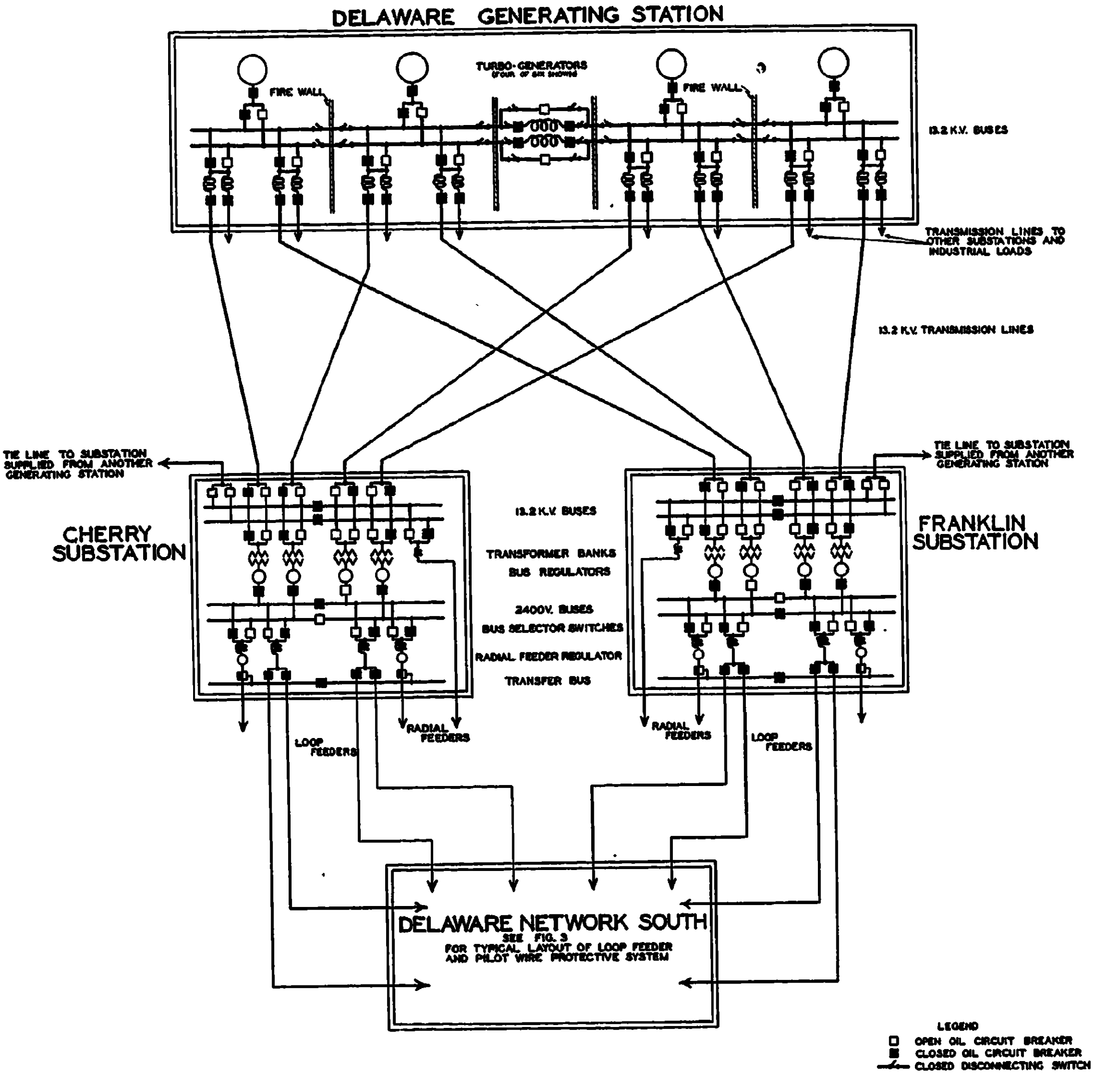

DELAWARE GENERATING STATION
TURBO-GENERATORS (FOUR OF SIX SHOWN)
FIRE WALL
FIRE WALL
13.2 K.V. BUSES
TRANSMISSION LINES TO OTHER SUBSTATIONS AND INDUSTRIAL LOADS
13.2 K.V. TRANSMISSION LINES
TIE LINE TO SUBSTATION SUPPLIED FROM ANOTHER GENERATING STATION
TIE LINE TO SUBSTATION SUPPLIED FROM ANOTHER GENERATING STATION
CHERRY SUBSTATION
FRANKLIN SUBSTATION
13.2 K.V. BUSES
TRANSFORMER BANKS
BUS REGULATORS
2400V. BUSES
BUS SELECTOR SWITCHES
RADIAL FEEDER REGULATOR
TRANSFER BUS
LOOP FEEDERS
RADIAL FEEDERS
RADIAL FEEDERS
LOOP FEEDERS
DELAWARE NETWORK SOUTH
SEE FIG. 3 FOR TYPICAL LAYOUT OF LOOP FEEDER AND PILOT WIRE PROTECTIVE SYSTEM
LEGEND
OPEN OIL CIRCUIT BREAKER
CLOSED OIL CIRCUIT BREAKER
CLOSED DISCONNECTING SWITCH

Fig. 1. Schematic diagram of typical power supply to a Philadelphia a-c. network area

Careful scrutiny of this diagram will reveal many details supplementing the accompanying text

Table I—Data Pertaining to the Philadelphia A-C. Network System—1930 Peak

		Delaware north	Delaware south	Schuylkill south	Totals December 1930
1.	Area in square miles operating network	0.413	0.467	0.376	1.256
2.	Maximum demand in kva. (network only)	8,023	9,897	9,682	27,602
3.	Number primary loop feeders	8	8	8	24
4.	Total normal capacity of loop feeders	10,620 kva.	9,600 kva.	12,320 kva.	32,540 kva.
5.	Average normal load per loop feeder	1,003 kva.	1,237 kva.	1,210 kva.	1,150 kva.
6.	Total length of loop feeder cable	70,400 ft.	99,800 ft.	92,400 ft.	262,600 ft.
7.	Average length per loop feeder	8,800 ft.	12,475 ft.	11,550 ft.	
8.	Total length of loop feeder cable between substation and first transformer bank	17,160 ft.	36,698 ft.	30,240 ft.	84,098 ft.
9.	Total length of loop feeder cable between substation and boundary of network area		21,292 ft.	6,805 ft.	28,097 ft.
10.	Number of unit sections on loops	57	70	72	199
11.	Average loop section length in feet	1,230 ft.	1,430 ft.	1,280 ft.	1,320 ft.
12.	Number of primary oil circuit breakers	49	62	64	175
13.	Installed transformer capacity kva	12,500	13,600	15,400	41,500
14.	Number of transformers (100 kva.)	125	136	154	415
15.	Number of transformer manholes	41	54	56	151
16.	Ratio normal loop feeder capacity to transformer capacity	85%	71%	80%	78%
17.	Ratio maximum coincident feeder demand to transformer capacity	64%	73%	63%	66%

3. Some 22 cable failures and three transformer failures have been isolated successfully without interruption to service in any unit-section other than that directly affected, and without impairing service to any customer. Cable failures have averaged one per 3½ unit-sections per year, or 12 per 100 mi. of operating cable per year, the relatively high average being due largely to external mechanical injury. Transformer failures were caused by water leakage and consequent insulation breakdown.

4. The first consignment of oil circuit breakers caused trouble by tripping out from vibration, a trouble relieved by proper mechanical corrections. Excepting one other instance—a failure caused by water leakage—these breakers have given satisfactory service and have required only a minimum of maintenance.

5. The operation of fuses in these network areas has demonstrated that secondary faults are quickly and selectively isolated, and that the sizes used are satisfactory. There have been no cases of fuses blowing when a fault did not exist in that particular section. When fuses have not blown, faults have cleared themselves; in two cases they burned clear within a few inches of the point of origin.

6. In the pilot-wire relay system field inspections to date have disclosed three cases of failure in the four-conductor (No. 4) rubber-insulated, lead-covered cable. Also two cases of incorrect cable connections and one defective current transformer were discovered. However, none of these six irregularities caused circuit-breaker operation.

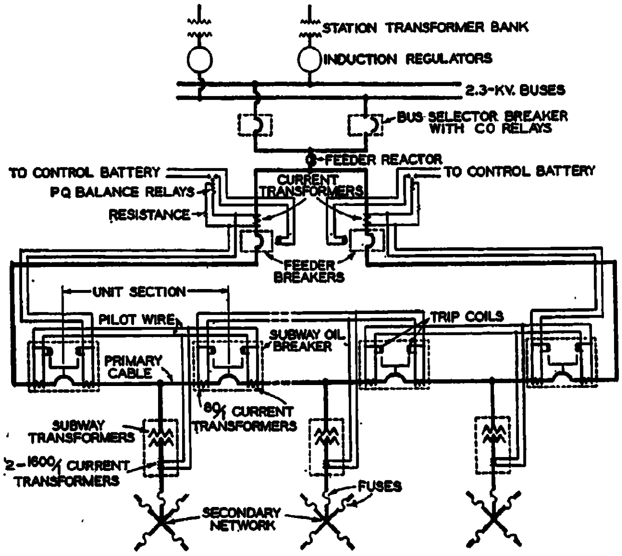


Fig. 2. (Above) Single-line diagram of pilot-wire relay protection system for a typical primary loop

It may be noted that only one transformer bank and associated cable is isolated in the event of a fault on the primary loop feeder

An inspection is made every three months by a group of five men to determine the condition of all equipment associated with the network. It is expected that with further operating experience the frequency of inspection may be reduced safely. In detail the inspections consist of:

1. Testing transformers, oil circuit breakers, and fuse boxes for water-tightness. The work involved in making equipment water-tight accounts for most of the inspection time.

2. Testing the entire pilot-wire relay system for grounds, open circuits, and short circuits.

3. Checking sensitivity of trip coils and operating mechanisms.

4. Looking for blown fuses and open secondary cable mains in the sectionalizing boxes.

5. Minor repairs and adjustments to all equipment as required.

Open breakers on the primary loop circuits are checked (1) by recording the hourly ammeter reading on each loop feeder, (2) by twice each week opening alternately the loop feeder ends, and (3) checking the approximate total currents under these test conditions. The current readings on each loop-end often indicate an open section and its approximate location.

CONSISTENCY IN A TEN-YEAR PLAN

Since the first Philadelphia a-c. network area was established in 1926 as an integral part of a ten-year program of changing the downtown business district from d-c. to a-c. distribution, the system plan initially adopted has been followed without fundamental change, and has proved amply flexible to meet changing load conditions. With the aid of an a-c. "system calculating board" the proposed system was laid out in detail to meet the general requirements:

1. That the network system as a whole should have sufficient spare capacity to insure against overloading any equipment during periods of unit-section or transformer outage; and

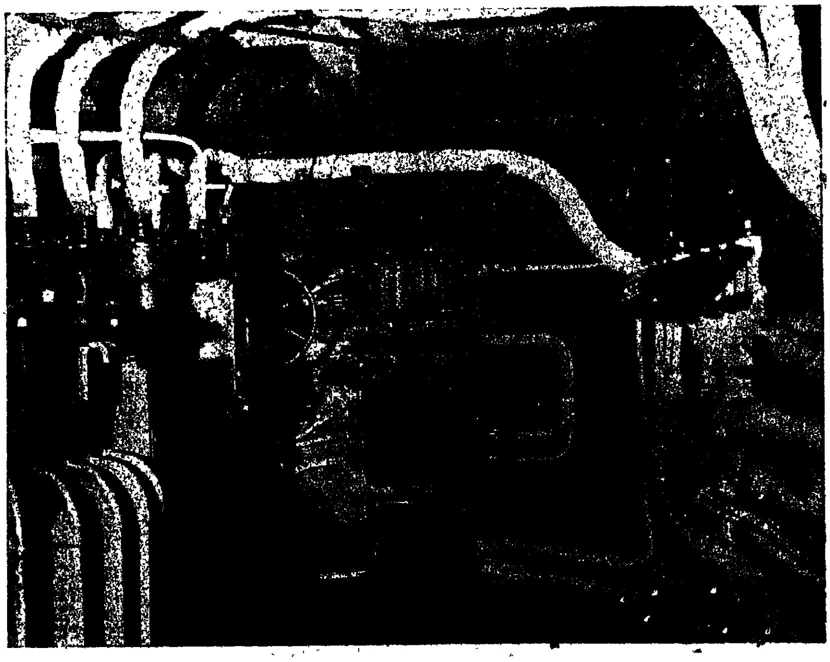


Fig. 3. (Right) Typical transformer manhole showing—left to right—transformer, oil circuit breaker, pilot cable junction boxes, and secondary sectionalizing boxes

Most manholes are 15 x 9 ft. in plan with 8-ft. headroom, and are located in the highway beneath the sidewalk. Two openings are covered by removable slabs, one of which has an open-grating lid and two openings for ventilating ducts which ducts extend from street surface to bottom of the manhole at each end

2. That adequate network voltage should be maintained under all conditions, including short-time (30 min.) loss of one of the two substations supplying any given area.

Both of these requirements have been proved in practical operation.

Synchronous Machine Constants

COMPANION papers "Calculation of Synchronous Machine Constants" by L. A. Kilgore and "Determination of Synchronous Machine Constants by Test" by S. H. Wright (see footnote) both of the Westinghouse Electric & Manufacturing Company, have been presented before the A.I.E.E. Until recently the theory of synchronous machines has required relatively few constants; a single value of reactance, usually called armature leakage, has been used to calculate the initial short-circuit current, and standard decrement curves have been applied to determine the rate of current decay. However, the need for greater accuracy in short-circuit and stability calculations has brought into quite general use the new theory involving symmetrical components. The various reactances and time constants affecting transient characteristics must be known in applying the new theory, and consequently there is a real demand for knowledge of these constants.

The paper by Mr. Kilgore presents a method of calculation for all the more important constants, except the subtransient time constant. The principle of superposition is applied to resolve the reactance accurately into components which can more readily be calculated. The induced current in the field and additional damping circuits are accounted for in a simple manner by applying the constant interlinkage theorem. Comparisons of test and calculated values are given, and formulas for the constants of both salient-pole and turbine generators are derived in the appendix.

Every designer of large synchronous machines has to meet this problem of calculating the constants and those who use the constants in other applications also are interested in knowing how accurately they can be calculated. Their application rather than their calculation has been the subject of most of the previously published information.

The paper by Mr. Wright, discusses the results of an investigation including extensive tests of the constants of various synchronous machines representative of those found in modern hydroelectric or steam-electric power systems. Although there is as yet no accepted set of definitions which standardize the meaning of these reactance constants, time constants, and resistances, they are discussed from a practical standpoint and methods for their determination from tests are described. Also are given details of the application of these methods to an extensive group of tests actually made.

These tests show the importance of such factors as saturation in the analysis of machines operating under short-circuit conditions. Saturation was found to be particularly important for turbine-generators, due largely to the inherently low reactance and therefore high short-circuit current of this type of machine. As a result, variations in some of the constants were found and are presented in the paper. The author advocates that unless otherwise qualified, reactances and time constants should be based on what are termed "saturated" values. Based upon the extensive tests performed, tables are given to show the values of the constants for various types of machines. These afford means of estimating the characteristic constants of the various synchronous machines that are found on the power systems of today.

Field Transients in Magnetic Systems

MAGNETIC CIRCUITS generally are composed of magnetically different materials which have different characteristics such as magnetization curves, electrical conductivities, and thermal properties. The most important distinction, however, lies in the use of laminated and solid iron parts, both of which show extreme behavior in the case of transient phenomena. When any change of the associated magnetic field takes place, eddy currents are produced in the iron, and these eddy currents produce a reacting magnetic field. This condition delays the rate of change of the resultant field. In the case of laminated iron parts, the very structure of the system limits the amount of eddy current to a negligible value. However, the delay of the growth of the magnetic field in solid iron parts is one of the most important factors in the operation of many types of electrical equipment.

Previous solutions of this general problem have been based upon special assumptions which do not take

---

Abstracted from "Calculation of Synchronous Machine Constants" (N . 31-103) by L. A. Kilgore, and "Determination of Synchronous Machine Constants by Test" (N . 31-114) by S. H. Wright, both presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Abstracted from "Field Transients in Magnetic Systems" (N . 31-115) by E. Weber, presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

accurate account of the interlinkage of eddy current and exciting current. Ernst Weber in an A.I.E.E. paper (see footnote) presents a complete mathematical solution of suddenly applying a d-c. voltage to an electromagnetic circuit composed of an electric coil with a partly laminated and partly solid iron core containing an air-gap. Starting from Maxwell's field equations for the eddy current and the magnetic field in the iron core, the solution of the time conditions is reached with the aid of Heaviside's operational calculus. The result is expressed by means of a time constant of the magnetic field, composed of the time constant of the electric circuit and a fraction of a newly defined time constant due to the eddy currents in the iron part. The influence of the various dimensions of the solid iron part on the rate of change of the magnetic field is shown quantitatively. The results of the method described are illustrated by a numerical example.

The method is of considerable importance in a number of practical applications, such as the operation of relays; in the pulling into step of synchronous motors; in the short-circuiting of and quick-response excitation of large alternators; in production schedules depending upon changes in speed of large industrial motors; in the proper performance of all motors in the field of transportation; and in all magnetic-electric systems where regulation is influenced by the magnetic inertia. This problem is not only electrically, but economically and mechanically, important since the design of such equipment depends upon the relative amount of solid iron which may be used in extreme cases without disturbing the required characteristics of operation.

Transient Oscillations in Distributed Circuits

OSCILLATIONS in transformer and other distributed windings have been subject to analysis both by test and calculation; the mathematical investigation of such oscillations is extended by L. V. Bewley (see footnote). In this paper, the nature of the initial, transient, and final distributions of potential are mathematically analyzed and discussed, showing the effects of the following:

1. Losses
2. Circuit constants
3. Neutral impedances
4. Applied wave shape
5. Available methods for controlling distribution

The losses in a transformer circuit during a high frequency transient are due to series resistance in the winding (including skin effect) and dielectric losses and leakage currents from the winding to ground and between points at different potentials on the winding. These losses have a four-fold effect on the character of the oscillations: (1) the amplitudes of the harmonic oscillations are decreased; (2) the frequencies of the harmonic oscillations are slowed down; (3) decrement factors are introduced; and (4) the final distribution is not linear. It is theoretically possible to choose such losses that all oscillations vanish.

In analyzing the effects of circuit constants, most distributed circuits may be classified under four ideal combinations: (1) self-inductance and ground capacitance (the transmission line); (2) self-inductance, series capacitance, and ground capacitance; (3) self- and mutual inductance, and ground capacitance; and (4) self-inductance and mutual inductance, series capacitance and ground capacitance (the transformer). The effects of these different combinations of circuit constants are described by equations and graphs in the complete paper. It is shown that they may be discussed from three different points of view: (1) fixed distribution plus harmonic standing waves; (2) fixed distribution plus harmonic traveling waves; and (3) simple traveling wave plus distortion terms. Complete sets of curves for the initial and final distributions are given.

A rigorous mathematical treatment for any generalized neutral impedance is not attempted, but two approximate methods of analysis are given. In the first method, the neutral voltage is determined by solving the approximate external equivalent circuit of a transformer, and, using this voltage as an applied wave; the corresponding distribution then is found and added to the distribution due to the wave at the line terminal and with the neutral grounded. This method is illustrated for a capacitance in the neutral. In the second method, the circuit consisting of self-inductance, ground capacitance, and series capacitance is used to represent the transformer, and the solution for the neutral voltage obtained by means of the Heaviside operational calculus. This latter method gives fairly good results for the neutral voltage, but only a rough approximation for the internal distribution.

The solutions are given for the following representative applied wave shapes, and the general method of analysis is specified: (1) infinite rectangular wave; (2) finite rectangular wave; (3) uniformly rising front; (4) typical lightning wave; (5) damped oscillation; and (6) sustained oscillation. The solution for each of these cases is illustrated either by graphs or cathode ray oscillograms, or both.

The control of the transient distribution is discussed with respect to: (1) maintenance of constant neutral

---

Abstracted from "Transient Oscillations in Distributed Circuits, with Special Reference to Transformer Windings" (No. 31-96) by L. V. Bewley, presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

conditions, and (2) control of the oscillations by shunt or series capacitances or combinations of both, by ground capacitance, and by losses. It is shown that while the addition of ground capacitance increases the amplitudes of the space harmonics, it slows the natural frequency of oscillation, and therefore may prevent the occurrence of abnormal voltage to ground before the applied terminal wave has disappeared. However, it increases the gradients along the winding, and therefore does not offer the ideal solution that their elimination provides. Stress is placed on the control of oscillations by the use of losses, particularly by shunt resistance with an exaggerated negative characteristic; and the possibility of a combined lightning arrester and tied-in shunt resistor for controlling the distribution is pointed out. There also is included in the paper a short historical sketch on this phase of transformer investigations, and a short bibliography.

Non-Linear Circuits for Relay Applications

Study and analysis of non-linear circuits reveal characteristics which mark them as capable of being adapted to a variety of special uses. A simple series circuit of this type is especially well adapted for relay applications, and obviates some of the undesirable features of mechanical relays.

By
C. G. SUITS

General Elec. Co.
Schenectady, N. Y.

No PRACTICAL problems lend themselves to solution by available mathematical tools as readily as do linear electrical circuits. In non-linear circuits, however, wherein the magnitude of the different elements of inductance, capacitance, or resistance, become functions of the current or other variables, the analytical problem is complicated greatly. Mathematical impedimenta need not intimidate the experimental approach, however, for many of the non-linear circuits may be studied in this manner with the simplicity characteristic of the more familiar circuits. In this connection it is probable that a lack of that potent aid to research—analysis—accounts in some degree for the present elementary state of development of this type of circuit.

Many so-called linear circuits containing ferromagnetic core material possess linear characteristics over their normal operating ranges, but do not even approximate linear operation during abnormal conditions. For this reason these supposedly linear circuits sometimes behave in a manner regarded as anomalous, when in reality such behavior is related directly to the fundamental *non-linear* nature of the circuits. Thus various types of instability in power circuits incorporating capacitance probably can be analyzed in terms of elementary non-linear circuits. A careful study and analysis of various circuits will reveal many applications not readily apparent. One application of this character consists in the use of a simple series non-linear circuit in conjunction with apparatus already available for a non-mechanical relay having practically ideal characteristics.

The voltage-current characteristic for a series non-linear circuit consisting of resistance, capacitance, and an iron-core inductance, may be seen in Fig. 1. The similarity between this characteristic and the characteristic for an ideal relay is evident at a glance. As may be seen from the curve, this circuit is "voltage sensitive," that is, at the critical voltage a large current rise may be observed in response to a small change in voltage. Thus at or near this critical point, a change in voltage of only 0.01 per cent may result in a 100 per cent increase in current.

An oscillographic study of the circuit of Fig. 1 reveals that the low-current region *A* is associated with the magnetically unsaturated region, or more properly the hysteresis region of the iron-core reactor, while in region *C* the current has risen to such values that saturation has taken place. Region *B*, or the critical part of the voltage-current curve, corresponds to that portion of the magnetization characteristic of the core material loosely referred to as the "knee," and in this region the instantaneous current rise is such that the instantaneous capacitance and inductance voltages are equal and opposite during some portions of the voltage

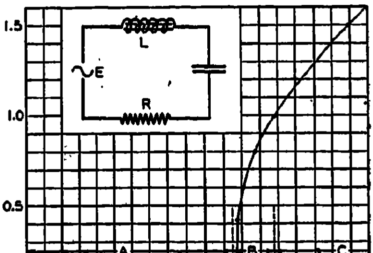


Fig. 1. Voltage-current characteristic for a series circuit containing as its non-linear element an iron-core reactor

---

Based upon "Studies in Non-Linear Circuits" (No. 31-37) presented at the A.I.E.E. winter convention, New York, Jan. 26-30, 1931.

cycle. In this limited region of resonance the peak value of current is limited only by resistance, and thus may be calculated from the d-c. resistance of the circuit and the corresponding instantaneous value of applied voltage.[8] This condition is illustrated by the oscillogram shown in Fig. 2. Here the cyclic period of resonance occurs during the interval indicated by arrows, and during this period also the current is at its peak value. This quasi-resonant state has been called non-linear resonance to distinguish it from linear resonance from which it differs in important respects. Non-linear resonance is analogous to linear resonance in that the current is resistance-limited, and that the sum of the reactance voltages is zero; it differs from ordinary resonance phenomena, however, in that the period during which the resonance condition

$$-l\frac{l}{C}\int i\,dt = L\frac{di}{dt} = K\frac{d\Phi}{di}\,\frac{di}{dt}$$

is satisfied, occupies but a small portion of each steady-state cycle.

APPLICATION TO A-C. RELAYS

A relay must possess in general two characteristic properties: (1) a non-linear actuating characteristic, and (2) capability of power amplification, which means that the ratio of controlled to consumed power must be high. The voltage-current characteristics of a series non-linear circuit make it admirably well adapted to fulfilling the first mentioned requirement. The second requirement may be obtained by combining this circuit with the saturable core reactor as shown in Fig. 3. The saturable core reactor (A.I.E.E. JOURNAL, Oct. 1924, p. 958-66) is essentially a special type of reactor having a-c. load windings and d-c. control windings so arranged that no power is transferred between the load and control circuits. In the arrangement shown in Fig. 3 the voltage across the capacitance in the resonant circuit is used to actuate the saturating reactor which in turn controls a load through its a-c. circuit.

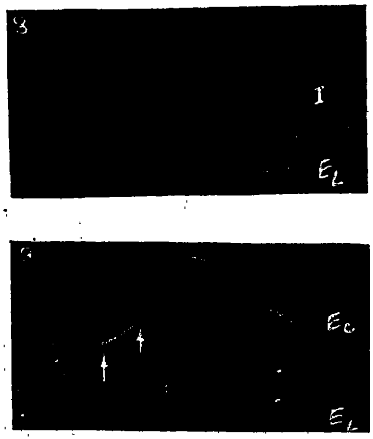


Fig. 2. Typical oscillograms showing voltage and current relations for range "B" of Fig. 1. Arrows denote range of non-linear resonance

I —current
E_L—inductance voltage
E_C—condenser voltage

Voltage-current characteristics for different parts of this relay arrangement also are shown in Fig. 3. Overall operating characteristics of the device are indicated in the curve I_3, which is a close approximation to the characteristics of an ideal relay. Curves are shown for two values of load resistance (R_2). From these two curves it is quite obvious that the ratio of "on" to "off" load current may be made as large as desired, it being a function of the design of the saturating reactor, and governed by the same considerations as in all circuits where this device is used.

Of some importance in this application is the amount of power which may be controlled in a relay of this type. For a saturable core reactor the power amplification factor is a function of the maximum and minimum values of impedance required, which are related in turn to the "on" and "off" load current. Theoretically, the power amplification of a reactor of this type is quite unlimited but practically a factor of 1,000 for an incandescent lamp load has not been exceeded to date. This present limit can be exceeded quite readily, however, by cascading the saturable reactors. Since there is no limit to the number of reactors which may be cascaded, accordingly there is no limit to the power amplification that may be obtained. It may be interesting to note that in an experimental set-up a power amplification of 10,000 is obtainable in only two stages, and with comparatively inefficient equipment.

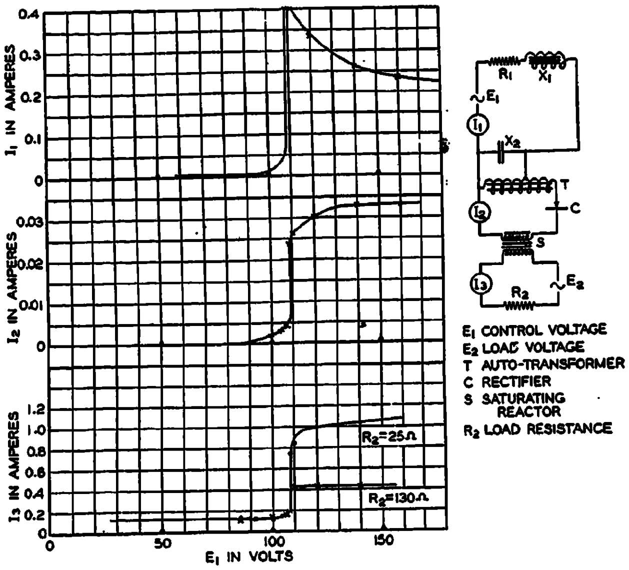


Fig. 3. A-c. relay made up of a series non-linear circuit and a saturable-core reactor with voltage-current curves for different circuit branches

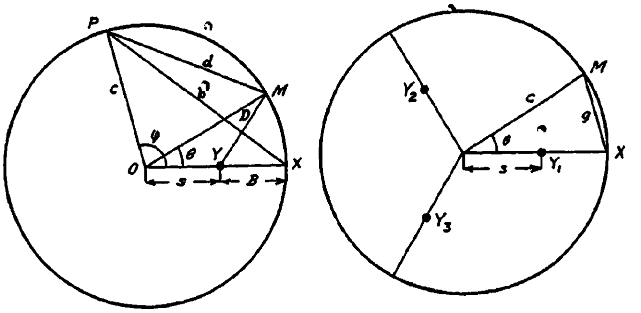
The sensitivity of resonant relays is limited by the characteristics of the resonant circuit and of the saturable reactor circuit. The most sensitive relay action is obtained when only a small amount of power is taken from the resonant circuit and in practical relays a 1 per cent change in voltage has been found sufficient to determine the "on" or "off" condition. Constancy of the control circuit frequency is another factor influencing to a certain extent the relay sensitivity. With a supply frequency of 60 cycles, however, variations in relay operating voltage are only about 1 per cent per cycle change in frequency. Means are available for obtaining still greater sensitivity, but up to the present time no application has required it.

Proximity Effect in Cable Sheaths

Formulas supplementing those previously published and making it possible to calculate the losses in cable sheaths simply and accurately are presented herewith. These cover a wid range of cases.

By
H. B. DWIGHT
Fellow A.I.E.E.

Massachusetts Institute of Technology, Cambridge



Figs. 1 and 2. Thin tube with enclosed filament (left) and three-phase cable with sheath (right)

LEAD SHEATHS of underground cables, being conductors two or three inches in width, usually will have noticeable circulating currents flowing in them due to the proximity of electric power currents. The calculation of the circulating currents and their losses is called a proximity effect calculation, and the result takes the form of a power series.

The problems encountered deal with current density, energy loss, and voltage drop. Certain of these are discussed in "Losses in Grounded Sheaths of Single-Conductor Cables," by H. B. Dwight, *Electric Journal*, Feb. 1924, p. 62. Methods are now available for applying these calculations to a wider number of cases and with increased accuracy.

Considering a very thin tube enclosing a filament as in Fig. 1, the current in the sheath is

$$i_{(\theta)} = -\frac{I}{\pi c t}\sum_{n=1}^{\infty}\frac{s^n}{c^n}\,\frac{l^4 + j\,l^2 n}{l^4 + n^2}\cos n\,\theta \qquad (1)$$

where

I = current in filament at Y

c = mean radius of tube in cm.

t = thickness of tube in cm.

s = distance in cm. from center of sheath to centers of the copper conductors

$$l^2 = \frac{\omega\, 2\,\pi\, c\, t}{\rho_s}$$

$\omega = 2\,\pi\, f$

f = frequency in cycles per sec.

ρ_s = resistivity of the tube in abohms per cm. cube

If there are currents in more than one location within the sheath, each produces its own sheath current independent of the others, and the total sheath current is obtained by addition. The result of distributed currents is given by integration.

ENERGY LOSS CALCULATIONS

The loss in the sheath of a three-phase cable is of importance with cables of large size. Referring to Fig. 2 the loss in the open-circuited sheath is given by the following expression, which was published by F. W. Carter, as eq. 19 in the *Proc. of the Cambridge Phil. Soc.*, V. XXIII, 1927, p. 905.

$$\frac{\text{Loss in lead sheath}}{\text{Loss in three copper conductors at 0 freq.}} = \frac{2\,a^2}{c\,t}\,\frac{\rho_s}{\rho_c}\sum_{n=1}^{\infty}\frac{s^{2n}}{c^{2n}}\left(\frac{l^4}{l^4 + n^2}\right)\sin^2\left(\frac{n\,\pi}{3}\right) \qquad (2)$$

where

a = radius in cm. of a solid copper wire of the same resistance as the stranded copper conductor

ρ_c = resistivity of copper

Calculations based on these formulas for three-conductor three-phase cables with open-circuited sheaths indicate that the sheath loss with a typical cable of 500,000 cir. mils per conductor is 5 per cent of the loss in the three copper conductors at 0 freq., and in a typical large cable of 1,000,000 cir. mils per conductor the sheath loss is 15 per cent of that in the three conductors.

The loss in short-circuited non-magnetic sheaths in a

From "Proximity Effect in Cable Sheaths" (No. 31-72) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

single-phase circuit is given by eq. 28 of the *Electric Journal* article previously referred to. However, this equation can be improved by making it more rapidly convergent for wide spacings between the cables. This is done by a slight change in the calculation, making the initial terms the same as in the usual impedance formula.

Using the notation of the present article let

$$P = \frac{-j\ \omega \operatorname{logn} \dfrac{s}{c}}{j\ \omega\ 2 \operatorname{logn} \dfrac{s}{c} + \dfrac{\rho_s}{2\pi c t}} \tag{3}$$

$$F_n = j\, l^2 (1 + 2P) \frac{c^n}{n\, s^n} \tag{4}$$

$$B = j\, l^2 \left[-2A \operatorname{logn} \frac{s}{c} + \sum_{k=1}^{\infty} \frac{c^k}{k\, s^k} F_k \right] \tag{5}$$

$$G_n = j\, l^2 \left[2A \frac{c^n}{n\, s^n} - \frac{F_n}{n} + \frac{c^n}{n\, s^n} \sum_{k=1}^{\infty} \frac{(n+k-1)\,!}{(n-1)\,!\,k\,!} \frac{c^k}{s^k} F_k \right] \tag{6}$$

n and k denote integers.

In the equations for B and G_n, $A = 0$. For C and H_n use the formulas for B and G_n respectively, except change A to B and F to G. Similarly for D and I_n, change A to C and F to H, and so on.

$$L = P + B + C + \ldots \tag{7}$$

$$M_n = F_n + G_n + H_n + \ldots \tag{8}$$

$$\frac{\text{Loss in sheath}}{\text{Loss in conductor at zero frequency}} = \frac{a^2}{c\,t} \frac{\rho_s}{\rho_c} \left[2\,|L|^2 + \sum_{n=1}^{\infty} |M_n|^2 \right] \tag{9}$$

$|L|^2$ is the square of the absolute value of L.

An approximate formula for this loss ratio is

$$\frac{2a^2}{c\,t} \frac{\rho_s}{\rho_c} |P|^2 \tag{10}$$

A typical example calculated for a 60-cycle, single-phase circuit with 2,000,000 cir. mil single-conductor cables indicated a sheath loss of 49 per cent of the loss in the conductor at 0 frequency, based on eq. 9, while the approximate formula eq. 10 indicated a loss of 41 per cent. This latter value is the same as would have been obtained using the well-known approximate formula

$$\text{Effective resistance} = R_c + \frac{R_s X_m^2}{R_s^2 + X_m^2} \tag{11}$$

When three single-conductor cables with short-circuited lead sheaths lie in a plane and carry balanced three-phase current, the losses in the two outer sheaths are not the same. The difference is great enough to justify adding a formula for the loss in the second outside sheath in addition to eq. 32 and eq. 34 of the previously mentioned *Electric Journal* article. Using the notation of that article, let

$$P_o = A_{co} + B_{co} + C_{co} + \ldots$$

$$P_n = A_{dn} + B_{dn} + C_{dn} + \ldots \quad n \neq 0$$

$$\frac{\text{Loss in sheath of second outside cable}}{\text{Loss in conductor at zero frequency}} = \frac{a^2}{c\,t} \left[2\,|P_o|^2 + |P_1|^2 + |P_2|^2 + \ldots + |P_n|^2 + \ldots \right] \tag{12}$$

Various problems in proximity effect and shielding in wires and thin tubes can be solved by these methods. Sheath losses are of sufficient importance to warrant being considered in all cases, even though frequently it will be desired only to compute the losses to show that they are practically negligible. In other cases, however, the effects are of engineering importance, and the design of conductors will depend upon the values computed.

Harmonic Generation by Grid Circuit Distortion

THE USUAL vacuum tube harmonic generators are fundamentally high distortion amplifiers operated under conditions of grid bias and plate voltage which, to distort the input voltage wave, utilize the non-linear relation between plate voltage and plate current. A paper published in the June 1931 issue of the A.I.E.E. TRANSACTIONS (see footnote) gives the result of an investigation into the possibilities of using the non-linear grid voltage-current characteristic to produce harmonics. Grid distortion can be utilized by operating the tube so that the grid goes positive for a part of each fundamental frequency cycle and then inserting in series with the grid lead an impedance across which the grid current impulses produce a voltage drop rich in harmonics, which then is amplified in the plate circuit.

The grid circuit distortion harmonic generator has the advantages of producing the harmonic in one circuit and developing the power in another, combined

---

Abstracted from "Harmonic Generation by Means of Grid Circuit Distortion" (No. 30-144) by F. E. Terman, (Asst. Prof. Elec. Engg., Stanford University, Calif.) D. E. Chambers (General Electric Co., Schenectady, N. Y.) and E. H. Fisher (Research Assistant, Stanford University, Calif.). Originally presented at the A.I.E.E. Pacific Coast convention at Portland, Ore., Sept. 2-5, 1930 (Eighth District 1930 prize paper). Published in A.I.E.E. TRANSACTIONS, V. 50, No. 2, June 1931, pp. 811-17.

with the very high distortion properties of the grid circuit. The result is that the grid distortion harmonic generator develops from 100 to more than 1,000 times as much power on the higher harmonics as does the usual plate distortion generator. Thus, when using a suitable parallel resonant circuit as the distorting grid impedance, a steady output of 135 volts effective has been obtained from a radio receiving tube on the 22nd harmonic. When the grid impedance consists of a large inductance it is possible to generate simultaneously at least 1/20th milliwatt of power on every harmonic up to the 50th. The grid circuit input power required to give these results is several hundred milliwatts in the case of the parallel resonant circuit, and considerably less when a grid inductance is used.

The paper gives the mechanism of operation, illustrated with oscillograms and harmonic spectra, and includes a discussion of the effect of circuit conditions on the operation of the grid distortion generator.

Discussion offered incident to the original presentation of this paper pointed out that:

> "In view of the fact that all of the results discussed in the paper are for a low fundamental frequency, it may be of interest to mention some work done . . . . at frequencies above 3,000,000 cycles, using tubes having ratings up to 250 watts . . . . The grid distortion harmonic generator using tuned grid impedance is characterized by a harmonic output that decreases very slowly as the order of the harmonic is increased. The result is that while the grid distortion method of harmonic generation has little, if any, advantage over the usual arrangement on the second and third harmonic, it is much superior on higher harmonics . . . . operative at fundamental frequencies above 3,000 kc., although adjustments were . . . . critical with unneutralized circuits. . . . a reasonable amount of power (has been obtained) on 8 meters with a generator drive by an 80-meter crystal."

The Trend in Dielectric Research

A résumé of some of the important advances made during the past year in the fields of physics and chemistry as applied to the fundamental theory underlying successful electrical insulation.

By
JOHN B. WHITEHEAD
Fellow A.I.E.E.
The Johns Hopkins University, Baltimore

THE PAST YEAR has been exceptionally rich in the results of dielectric research. Rather than attempt a review of all the new work which has come to my attention, I prefer to point out what seems to me to be an outstanding feature of the year's work, namely, an unusual intensity of the study of insulating liquids and some of the outstanding results thereof.

Several investigations are under way on the electrical properties of pure hydrocarbon liquids. From one of these there is some indication of a correlation between conductivity, as measured with continuous potential, and well recognized molecular properties. For the most part, however, the outstanding results of experiments of this character are to show that it is always possible, by further distillation and purification, to lower the conductivity still further. Values of conductivity of 10^{-18} and 10^{-19} mhos part are reported. These values always pertain to the long-time continuous voltage measurement and the volt-ampere characteristics show a pronounced saturation condition.

From the standpoint of such desirable insulating qualities as high dielectric strength, low dielectric loss, and low rate of deterioration due to whatever cause, these low values of conductivity are no indication of special value. In the matter of dielectric loss, for example, such pure liquids show losses under alternating stress which are far greater than may be accounted for by the final conductivity. The losses are completely accounted for, however, by an initial brief and constant conductivity which may be measured by oscillograph as shown by experiments in my own laboratory at Johns Hopkins University. The nature and type of the ions involved in this initial conductivity as yet are uncertain and present an interesting and important problem. It is of special interest to note that certain highly refined oils in the commercial class may, by similar treatment, have their final conductivity reduced to the same order of magnitude as that pertaining to the chemically pure simple hydrocarbon. In these cases, the ratio of the initial (0.002 to 0.01 sec.) to final (1 min. or more) conductivity may be as great as 500:1.

Essentially full text of the annual report of Doctor Whitehead as chairman of the committee on electrical insulation, division of engineering and industrial research, National Research Council, as presented at the fourth annual meeting and conference of that committee held at Harvard University, Cambridge, Mass., November 13 and 14, 1931.

The value of this ratio for the commoner, but good, insulating oils is from 4:1 to 10:1. The great differences in these ratios is caused by the differences in values of the final conductivities. The initial conductivity of the highly purified liquids approaches in value that of the commoner oils. In all cases a dielectric loss in the oil alone is accounted for completely by the initial conductivity.

COLLOID THEORY OF DIELECTRIC BEHAVIOR

There is increasing evidence that the electric ions involved in the dielectric loss in oils are larger than molecules. Attention already has been called to the possibility of this by Prof. J. W. Williams of the University of Wisconsin. In a series of papers stretching over the last few years, Professor Böning of Tung-Chi University has developed a theory of dielectric behavior based upon the properties of colloids, which he has applied experimentally and qualitatively, at least, to all the important phenomena appearing in the application of dielectrics as insulators. Briefly, the theory is as follows: All liquid insulators such as oil contain traces of colloidal particles the surfaces of which attract electric ions of one sign and hold them tight through the phenomenon of adsorption. The charges may be positive or negative according to the material, and the charged colloidal particles attract to themselves liquid ions of the opposite sign, of which there always are some present. The aggregate, therefore, consists of a double layer of opposite charges of which, however, the outer layer is very much more loosely bound than the inner. Under a sufficiently strong electric field the outer layer is detached and passes relatively rapidly to one electrode. The charged colloid particles thus left, owing to their size and mass, move slowly towards the opposite electrode. In the neighborhood of that electrode these particles may accumulate, forming a space charge, and thus reducing the field in the middle region and raising it near the electrode.

Experimental evidence of the presence of these space charges was presented several years ago by Whitehead and Marvin, and other similar evidence has been presented more recently by Schaefer. Böning recently has shown experimentally the presence of an increase of hydrostatic pressure under one electrode due to the accumulation of space charges. He invokes this phenomenon as an explanation of a condition sometimes observed in high voltage cables in which the compound appears to have migrated away from the central conductor. The space charges have low mobility and are evident only in studies with continuous voltage. The space charges as such do not accumulate at ordinary alternating frequencies, say 60 cycles, and the losses in oils at these frequencies are due to the oscillatory or perhaps rotatory motion of the particles or aggregates. They may be removed temporarily by the long application of a continuous field with consequent temporary reduction of loss.

COLLOIDS VS. DIELECTRIC STRENGTH

The influence of the presence of colloids upon the dielectric strength of oils also is being studied. According to Böning, as the amount of colloid material in purified insulating oils of several types increases up to 0.02 per cent there is a sharp reduction of dielectric strength to about 80 per cent of that of the pure oil. Greater proportions of colloid material, however, seem to have no increased effect. The breakdown strength under continuous voltage is 60 per cent of that under alternating stress. These results are said to be in general accord with the theory of space charges arising in the adsorption of ions of one sign and the resulting space charge and high stress near one electrode. Beyond a certain concentration of colloid particles there is no further lowering of dielectric strength because the particles tend to aggregate in large groups with corresponding reduction of the total adsorbing surface.

Further light on the nature of the breakdown of liquids is found in one of the frequent papers by Inge and Walther describing studies of the dielectric strength of xylol when carefully freed of dissolved gases by successive distillation. When so prepared, the breakdown strength of this liquid is independent of the pressure over a wide range, and independent of temperature for continuous and impulse voltages. There is, however, a continuous decrease of the breakdown alternating voltage with increasing temperature. The conclusion is reached that the breakdown in liquids is associated with the boiling point. Gas lowers the boiling point and facilitates breakdown. It would appear that the lowering of breakdown under alternating stress is due to increased local temperature caused by the back-and-forth motion of the colloid particles previously referred to, thus leading to breakdown, somewhat in accordance with the proposal of Gunther-Schultz. As related to this question of the picture of the nature of breakdown, there also may be mentioned the interesting report by Gemant of the photographic record of tiny local discharges within the oil before final failure.

LOW FREQUENCY LOSSES

Several papers have appeared discussing the possibility that dielectric losses at low frequencies may be occasioned by polar-molecular orientation in the Debye sense, as suggested by Kitchin and Mueller two years ago. Of these may be mentioned especially the work of Kirch and Riebel, who have reported several studies on oil-resin mixtures in various properties over a range of frequency from 50 to 10,000 cycles and in the temperature range from −30 to −160 deg. cent. These authors present a qualitative analysis of their results strongly supporting their proposal that the changes in power factor and dielectric constant with temperature and frequency are due to dipole orientation.

Ornstein and Willemse have presented other evidence in favor of molecular orientation as a cause of dielectric loss. They measure the Kerr effect, the dielectric loss, the temperature coefficient of dielectric constant, and the viscosity of a basic petroleum oil and eighteen different samples or cuts from the same oil by the separation of different compounds and their successive purification. Their results are presented in a series of diagrams in which the samples are arranged in horizontal rows, the several rows representing different groups of definite chemical character and the samples in each row being of different degrees of refinement. Correlation now is looked for in the changes in those electric properties dependent upon polar orientation as between the various groups and the respective samples in each group. Close correlation is found between changes in the value of the Kerr constant, the temperature change of dielectric constant, and in the values of dielectric loss, as well as in other properties. The whole presents a very convincing picture.

However, sharp exception to these proposals has been taken by A. Gemant in several papers, as well as in his interesting text, "Electrophysik der Isolierstoffe." In particular, he recently has reported a series of studies, similar to those of Kirch and Riebel, in which he shows that the oil carefully freed of colloids shows also the power factor variation attributed to polar molecules and that the increases due to the addition of colloid material by no means are proportionate to the amounts added. Further, he shows that similar changes may be brought about by the addition of non-polar impurities. He presents an equally convincing picture that the effect in question may be accounted for by the conductivity due to impurities and the consequent variations in structure, and that the variations of loss and power factor in the low temperature range for oils are in accordance with the Maxwell theory of absorption as extended by Wagner. He reaches the conclusion that losses due to polar molecules can occur only in frequencies at 10^4.

If time permitted, I should like to review briefly the important contributions from Rogowski, Joffé, Inge and Walther, and von Hippel, on the conductivity and electric breakdown in crystals. These contributions constitute notable extensions of present knowledge of the mechanism of molecular failure under electric stress. Reference to these and to all other papers mentioned will be found in the list which accompanies this report. These indicate that, as stated previously, the past year has been exceptionally rich in the results of dielectric research; it is extremely interesting to note also that the studies of engineers engaged in the direct application of dielectrics as insulators are approaching and supporting each other to a far greater extent than ever before.

Monograph Publication

One of the most important accomplishments of the year has been the appearance of the first of a series of monographs on dielectrics and insulation, which are to be published under the auspices of the N.R.C. committee on electrical insulation. The title of this first volume is "The Nature of a Gas," and its author, Prof. L. B. Loeb. The publisher is John Wiley & Sons. This is a remarkably clear and interesting exposition of recent knowledge and theory of the electrical properties of gases. It constitutes a most auspicious opening of a series which should be of great value, and the extension of which will constitute one of the committee's chief future efforts. Other monographs now in preparation are:

Electric Discharge in Gases, K. T. Compton and Irving Langmuir.

Conduction in Gases, J. Slepian and R. G. Mason.

Liquid Dielectrics, Dr. Andreas Gemant.

Solid Dielectrics, C. F. Hill, W. S. & M. Co.

The Electrical Properties of Glass, Dr. J. T. Littleton, Corning Glass Works.

Chemical Effects in Electric Discharge, George Glockler and Doctor Lind.

Bibliography

In presenting the following bibliography, no attempt has been to make it all-inclusive, and minor errors and inconsistencies may have crept in. It is believed, however, to contain many important publications on dielectric research and related subjects.

Physics, Chemistry and Theory

X-Ray Studies of Motions of Molecules in Dielectrics Under Stress, R. D. Bennett. *Jl. Franklin Inst.*, April 1931, p. 481. (Shows that after solidifying under stress paraffin gives an unsymmetrical halo when an x-ray beam passes through. No definite conclusions except molecules shifted.)

Conductivity of Crystals, A. Joffe. *Zeits. Phys.*, 62, 1930, p. 730. (Opposing Smekal and Rogowski.)

Concentrated Space Charges in Iceland Spar, A. Joffe. *Zeits. Phys.*, 66, 3, 4, 1930, p. 148. *Science Abstracts 1348.* (The concentrated high voltage space charge and its distribution in a thin cathode layer have been directly measured by grinding off the surface.)

Dielectric Polarization of Pure Organic Compounds, Morgan and Lowry. *Jl. Phys. Chem.*, Nov. 1930. (A series of measurements of molecular moments. No special bearing on insulating properties typical of a number of such studies. Connection not obvious as yet.)

Currents in Dielectrics, G. Guebeu. *Phil. Mag.*, 69, Feb. 1931, p. 405. (Mathematical development of currents in dielectrics due to polar molecules and due to ionic conduction; proposes an expression made up of their sum for total dielectric current. No experiments or check.)

Polar Molecules, S. O. Morgan. Washington meeting of N.R.C. committee on electrical insulation, Nov. 1930.

Theory of Absorption, Loss, Etc., Murphy Lowry, work at Bell Telephone Laboratories.

Passage of Electricity Through Solids, Nasledow and Scharawsky. *Ann. Phys.*, 5, 4, 1930, p. 429. (Polarization e.m.f. and appl. .m.f.—x-radiation increases residual charge and slower decay of charging current.

Dipole Theory, S. Whitehead. *Phil. Mag.*, 9, 1930, p. 865.

The Dependence of Polarization E.M.F. and True Conductivity of Crystals on the Field Strength, Berau and Quittner. *Zeits. Phys.*, 64, 11 and 12, 1930, p. 760.

Dielectric Polarization in Liquid Mixtures, N. N. Pal. *Phil. Mag.*, 63, 10, 1930, p. 265.

Space Charge, Colloids, and Properties of Dielectrics

Space Charge, Colloids, and Properties of Dielectrics

Oil Resin Mixtures, Bormann and Gemant. *Siemens, Konz.* (Power factor maximum at lower temperatures a Maxwell-Wagner and not a Debye effect.)

Properties of Oil Resin Mixtures, Kirch and Riebel. *Arch. Elek.*, 24, Nov. 7, 1930, p. 553.

Colloidal Anomalies of Petroleum Oils, Prausnitz. *Kolloid Zeits*, 51, June 1930, p. 359.

Cataphoresis in Rotating Fields, Colloid Parts, Pugh and Swartz. *Phys. Rev.*, Nov. 1.

Field Distribution in Liquids, Schaefer. *Zeits. Physik*, 62, 9, 10, p. 585.

Importance of Colloid Behavior of Insulating Liquids and Solids, J. W. Williams. Lecture at Washington meeting of N. R. C. committee on electrical insulation, Nov. 1930.

Breakdown

Influence of Colloid Suspensions on Dielectric Strength of Oils, P. Boning. *Zeits. fur Tech. Phys.*, 4, 1931, p. 200. (Up to 0.02 per cent by weight colloid asphalt reduces dielectric strength to about 80 per cent value for pure oil, thereafter no further reduction with more colloids.

Dielectric Strength of Degassed Liquids, L. Ingo and A. Walther. *Zeits. fur Phys.*, 9, 1930, p. 369. (Dielectric strength independent of pressure in degassed liquids—d-c. and a-c. and impulse. D-c. and impulse independent of temperature, but a-c. decreases with increasing temperature.)

Breakdown in Solids, Inge and Walther. *Arch. Elek.*, 25, Jan. 27, 1931, p. 21. (Showing that surface gradients at breakdown may be much higher for small radius conductors than those for parallel electrodes, notably in sulphur, suggesting corona effect in gas.)

Space Charge and the Breakdown of Gases, Rogowski. *Arch. Elek.*, Dec. 5, 1930, p. 679. (Positive space charge at negative electrode leads to the avalanche type of generation of new electrons; computation of the condition leading to rough agreement with the theory.)

The Theory of Thermal Breakdown in Solid Dielectrics, P. H. Moon. A.I.E.E. Trans., V. 50, 1931, p. 1008. (Discussion of theory as developed by Fock; extension and experimental results.)

Losses and Power Factor; Deterioration of Insulation

Influence of Colloid Suspensions on Dielectric Strength of Oils, P. Boning. *Zeits. fur Tech. Phys.*, 4, 1931, p. 200.

Influence of External Corona Discharges on Life of Impregnated Paper Cables, *Elec. Testing Lab. Report 31 W-3912.*

Power Factor Tests of Bushings and Insulators as Indications of Life. *Elec. World*, Aug. 29, 1931.

Dielectric Loss in Oils, A. Gemant. *Zeits. fur Tech. Phys.*, 12, 1930, p. 544. (Criticizing Ornstein and Willemse.)

Influence of Pressure on Dielectric Strength of Dry Paper, A. Gemant. *Arch. Elek.*, 25, 1931, p. 181. (At low pressures paper is stronger than air, at high pressures less so.)

Electrophotographie von Isolierstoffe, A. Gemant. *Zeits. Tech. Phys.*, 5, 1931, p. 250.

Paragutta, New Material for Submarine Cables, Kemp. *Bell Syst. Tech. Jl.*, Jan. 1931.

The Gas Content of Paper in Its Bearing on the Electrical Properties, Kogert. *Kunstoffe*, 21, No. 2, Feb. 1931. (The evolution of gas under oil is shown to be due to moisture, to acetone solubility, and to mechanical structure. The more rapid the gas evolution with increase of temperature, the poorer the electrical properties of the paper.)

Electric Loss and Electric Dipole Moment in Transformer Oil, Ornstein and Willemse. *Zeits. fur Tech. Phys.*, 9, 1930, p. 345. (Correlation of several factors over frequency range 50 to 10^6 cycles, all pointing to dipole loss.)

Some Electrical Characteristics of Cable Oils, H. H. Race. A.I.E.E. Paper No. 31-47. (Oil test cell; correlation of a-c. and d-c. 1-min. measurements.)

Oil Losses at High Frequencies, Vogler. *Eleck. Nach. Tech.* (Losses in oils at high frequencies 10^6 to 1.3×10^7, calorimeter method; power factor is indication of frequency and losses; no evidence of molecular polarity.)

Tests of Insulating Oils, Weiss and Solomon. *R.G.E.*, 28, July 2, 1930, p. 61. (Extensive study of oxidation and depreciation.)

Dielectric Research, Welo's work with the General Cable Corp.

Conductivity of Insulating Oils II, J. B. Whitehead. A.I.E.E. Trans., V. 50, No. 2, June 1931, p. 695.

Fundamental Properties of Impregnated Paper, J. B. Whitehead and W. B. Kouwenhoven. A.I.E.E. Trans., V. 50, No. 2, 1931, p. 699.

Simultaneous Faults on Three-Phase Systems

FROM published records of flashovers on double-circuit towers which have tripped out both circuits, and from opinions expressed by operating engineers of various power companies, approximately 20 per cent of faults occurring on double-circuit towers involve conductors of both circuits. In addition to these, instances have been reported where faults in substations have involved conductors of circuits not on the same towers. "It seems worth while therefore," states Edith Clarke (A'23) of the General Electric Company, Schenectady, N. Y., in a current A.I.E.E. paper, "to have in convenient form, methods for calculating short-circuit currents, and of determining the stability limit of a system when faults occur simultaneously at two separate and distinct points of the system."

The method of symmetrical components, introduced by C. L. Fortescue (A.I.E.E. PROCEEDINGS, Vol. 37, June 1918, p. 629-716) and now being used extensively to determine short-circuit currents and stability limits during transient conditions, have been extended by the author to apply to three-phase systems during simultaneous faults at two or more points. In the positive phase diagram, a general equivalent circuit is developed to replace two simultaneous faults involving any combination of the six conductors. An approximate equivalent circuit to be used with a d-c. calculating table when resistance is neglected also is given. In addition, special equivalent circuits are employed to replace two simultaneous faults and the lines upon which they occur, when these lines are unloaded feeders radiating from a common point or lines of equal impedances bused at both ends.

In the discussion on this paper (A.I.E.E. TRANSACTIONS, Vol. 50, September 1931, p. 939-41), the author's methods were shown to be of great practical value especially where two or more circuits are strung on the same towers. Some cases of trouble were reported on faulty circuit structures which involved two lines going to entirely different parts of the system. The paper enables protection engineers to work out the complete story of any type of simultaneous fault in quite a reasonable length of time, from which information relay settings may be established. Although developed specially for use with grounded systems, the discussion brought out also the fact that the method may be adapted to the calculation of fault currents and voltages on ungrounded systems which are quite common in Europe.

Abstracted from "Simultaneous Faults on Three-Phase Systems" by Edith Clarke, (No. 31-60) presented at the A.I.E.E., Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

News
Of Institute and Related Activities

Winter Convention Presents Elaborate Program

CURRENT engineering improvements in the art, resulting from field, laboratory, and operating experiences will be presented and discussed in the fourteen technical sessions to be held during the A.I.E.E. winter convention, with headquarters in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 25-29, 1932. In addition to the excellent technical program there will be interesting inspection trips and numerous entertainment features, with a specially arranged program for the visiting ladies.

TECHNICAL SESSIONS

The technical sessions have been planned so that the interests of any groups may not conflict at parallel sessions and yet subjects of interest to the same groups may be found scheduled close together. Thus those engaged in the fields of power generation, transmission, and distribution will find the sessions on protective devices, distribution circuit lightning protection, selected subjects, and system stability, of particular interest. Those chiefly interested in theory should find the latter session to be of particular interest as well as the sessions on instruments and measurements, general circuit theory, and research. All of the sessions so far mentioned will be held during the first three days of the convention. Designers and electrical manufacturers should find much material of unusual interest in the sessions scheduled for Thursday and Friday; namely two sessions on electrical machinery, one on transportation, and another on electric welding. A session on electrochemistry and electrometallurgy which is of both theoretical and basic practical interest also will be presented on Thursday morning. Friday will be devoted primarily to communication subjects although the papers presented in the symposium on time, and time services, should have a broad general appeal. With a program of such broad scope and timely interest those attending should have little difficulty in finding sessions of unusual interest along their particular lines of endeavor.

ENTERTAINMENT

A buffet supper and smoker with entertainment will be held on Tuesday evening. On the following evening both the Edison Medal and the John Fritz Medal will be presented to the respective medalists. On Thursday evening the annual social event, the dinner dance, will be held. In addition, there will be a number of interesting inspection trips and the special program for the ladies in attendance; more information pertaining to these features will be announced at a later date. Monday and Friday evenings have been left open to afford out-of-town guests an opportunity for theater going, the visiting of friends or making other engagements.

REDUCED RAILROAD RATES

Under the certificate plan reduced railroad rates will be available to members and guests who attend the convention; only half fare need be paid on a return trip over the same route, provided a total of at least 100 certificates are deposited at the registration desk. Rates apply to all who attend the convention and to dependent members of their families. Each member or guest should obtain a certificate when purchasing his one-way ticket to New York, explaining to the ticket agent that he wishes the certificate authorized by the passenger associations for the winter convention of the American Institute of Electrical Engineers.

On arriving at the convention the certificate should be deposited at the registration desk. There it will be held for validation by a railroad representative and if 100 or more certificates are validated, these certificates will be returned to the owners. By presenting the validated certificate when purchasing return ticket, only half fare will be charged. Local ticket agents should be consulted regarding conditions affecting this plan, as it applies only within certain dates, depending upon the territory. *Everyone* whose one-way fare is more than 66 cents *should get a certificate* whether or not he intends to use it. *By neglecting to do so others may be deprived of considerable saving.*

COMMITTEES

The 1932 winter convention committee is constituted as follows: E. B. Meyer, *chairman*; O. H. Caldwell, H. P. Charlesworth, Harold C. Dean, W. H. Harrison, C. R. Jones, G. L. Knight, C. E. Stephens and R. H. Tapscott.

Chairmen of the subcommittees are: C. E. Stephens, convention executive committee, with C. R. Jones as vice-chairman; G. W. E. Draper, smoker; E. J. Johnson, dinner dance; W. R. Smith, inspection trips; and Mrs. E. B. Meyer, ladies' entertainment.

SCHEDULE OF EVENTS

Monday morning and evening have been left open for committee meetings. Capital letters A, B, etc., denote technical sessions.

Monday, January 25

10:00 a. m.	Registration
2:00 p. m.	Opening of Convention
	A—Protective Devices
	B—Instruments and Measurements

Tuesday, January 26

10:00 a. m.	C—Symposium on Distribution Circuit Lightning Protection
	D—General Circuit Theory
2:00 p. m.	E—Research
	F—Selected Subjects
6:00 p. m.	Buffet Supper and Smoker

Wednesday, January 27

10:00 a. m.	G—Symposium on System Stability
1:15 p. m.	Inspection Trips
2:00 p. m.	Board of Directors Meeting
8:30 p. m.	Edison Medal and John Fritz Medal Presentations

Thursday, January 28

10:00 a. m. H—Electrical Machinery
I—Electrochemistry and Electrometallurgy
2:00 p. m. J—Electrical Machinery
K—Transportation
7:30 p. m. Dinner Dance

Friday, January 29

10:00 a. m. L—Symposium on Time and Time Services
2:00 p. m. M—Communication
N—Electric Welding

Tentative Technical Program

Monday—2:00 p. m.

A—Protective Devices

A New High Speed Distance Relay with Composite Impedance—Reactance Characteristic, S. L. Goldsborough and W. A. Lewis, Westinghouse Elec. & Mfg. Co.

The Theory of Oil Blast Circuit Breakers, D. C. Prince, General Electric Co.

*The Practical Application of the Oil Blast Principle of Circuit Interruption, R. M. Spurck, General Electric Co.

*Recent Developments in Arc Rupturing Devices, R. C. Van Sickle and W. M. Leeds, Westinghouse Elec. & Mfg. Co.

Extinction of A-C. Arcs in Turbulent Gases, T. E. Browne, Jr., Westinghouse Elec. & Mfg. Co.

B—Instruments and Measurements

High Voltage Bridge for Measurements of Cable with Grounded Sheaths, C. L. Dawes and A. F. Daniel, Harvard University

A High Sensitivity Power Factor Bridge, W. B. Kouwenhoven and Alfredo Banos, Jr., The Johns Hopkins University

*Capacitance and Power Factor Measurement by the Capacitance Bridge, R. P. Siskind, Harvard University

*Aging and Elastic Hysteresis Instrument Springs, R. W. Carson and P. MacGahan, Westinghouse Elec. & Mfg. Co.

*An Automatic Oscillograph, C. M. Hathaway and R. C. Buell, General Electric Co.

*The Photoelectric Recorder, C. W. LaPierre, General Electric Co.

Tuesday—10:00 a. m.

C—Symposium on Distribution Circuit Lightning Protection

*Lightning Protection of Transformer Secondaries, C. Francis Harding and C. S. Sprague, Purdue University

*Field Studies of the Protection of Distribution Transformers by Lightning Arresters, Including the Effect of Interconnection, K. B. McEachron, General Electric Co.

*The Protection of Distribution Transformers from Failures Due to Lightning, A. M. Opsahl, Westinghouse Elec. & Mfg. Co., A. S. Brookes and R. N. Southgate, Public Service Electric and Gas Co.

*Studies in Lightning Protection on 4,000-Volt Circuits—III, D. W. Roper, Commonwealth Edison Co.

*Investigation of Lightning Protection for Distribution Transformers, T. H. Haines and C. A. Corney, The Edison Electric Illuminating Company of Boston

*Distribution System Lightning Studies by Philadelphia Electric Company, H. A. Dambly, H. N. Ekvall, and H. S. Phelps, Philadelphia Electric Co.

D—General Circuit Theory

Equivalent Circuits, F. M. Starr, General Electric Co.

Transient Oscillations of Mutually Coupled Windings, L. V. Bewley, General Electric Co.

The Geometrical Circuits of Electrical Networks, R. M. Foster, American Tel. & Tel. Co.

Tuesday—2:00 p. m.

E—Research

Some Fundamental Theory and Experiments on Electrical Precipitation, A. W. Simon and L. C. Kron, Tennessee Coal, Iron and Railroad Co.

Radio Interference from Corona on High Voltage Insulators, F. O. McMillan, Oregon State Agricultural College

*Predetermination of the A-C. Properties of Dielectrics from the Continuous Potential Characteristics, J. B. Whitehead and A. Banos, Jr., Johns Hopkins University

The Breakdown of Glass with Alternating Potentials, N. D. Kenney, A. M. Luery and J. D. Moriaty, Standard Cable Corp.

Relationships among the Magnetic Properties of Magnet Steels and Permanent Magnets, K. L. Scott, Western Electric Co.

F—Selected Subjects

*Introductory Statement—Steam *vs.* Electrically Driven Auxiliaries for Steam Power Stations, F. H. Hollister, Sargent and Lundy, Inc.

Steam Driven Auxiliaries for Power Plants, W. Poole Dryer, Stone and Webster, Inc.

Electrically Driven Auxiliaries for Steam Power Stations, L. W. Smith, Sargent and Lundy, Inc.

*An Improved Type of Limiting Gap for Protecting Station Apparatus, A. O. Austin, Ohio Insulator Co.

Wednesday—10:00 a. m.

G—Symposium on Stability

*Proposed Definitions of Terms Used in Power Stability Studies—Report of Subject Committee on Definitions, H. K. Sels, Chairman

*Recommended Current Decrement Curves—I, W. C. Hahn, General Electric Co., and C. F. Wagner, Westinghouse Elec. & Mfg. Co.

*Recommended Decrement Curves—II, W. C. Hahn, General Electric Co.

*Recommended Decrement Curves—III, C. F. Wagner and S. H. Wright, Westinghouse Elec. & Mfg. Co.

*Operating Experience of the Philadelphia Electric Company System from the Stability Point of View, R. A. Hentz and J. W. Jones, Philadelphia Electric Co.

Thursday—10:00 a. m.

H—Electrical Machinery

*An Induction Motor With Paralleled Rotor and Stator, A. G. Conrad and R. G. Warner, Yale University

*Some Considerations in the Design of Damper Windings for Synchronous Motors, C. C. Shutt, Westinghouse Elec. & Mfg. Co.

*Surge-Proof Transformers, H. V. Putman, Westinghouse Elec. & Mfg. Co.

*Effect of Transient Voltages on Power Transformer Design IV—Transformation of Lightning Waves to Secondary Windings, K. K. Palueff and J. H. Hagenguth, General Electric Co.

I—Electrochemistry and Electrometallurgy

Power Losses in Electrolytic Condensers, F. W. Godsey, Jr., The Safety Car Heating and Lighting Co.

Film Characteristics of Electrolytic Condensers, F. W. Godsey, Jr., The Safety Car Heating and Lighting Co.

*The Effect of Polar Molecules in Dielectrics, W. N. Stoops, Westinghouse Elec. & Mfg. Co.

*Cobalt Magnet Steel, P. H. Brace, Westinghouse Elec. & Mfg. Co.

Thursday—2:00 p. m.

J—Electrical Machinery

*Commutation Considered as a Switching Phenomenon, R. E. Hellmund and L. R. Ludwig, Westinghouse Elec. & Mfg. Co.

Equalizing Currents in the Armature of a D-C. Machine, R. M. Baker, Westinghouse Elec. & Mfg. Co.

Calculation of the No-Load Damper Winding Loss in Synchronous Machines, E. I. Pollard, Westinghouse Elec. & Mfg. Co.

*Mathematical Theory of Sine Wave Generators, L. P. Shildneck, General Electric Co.

K—Transportation

Engineering Features of "Three Power" Locomotives, F. H. Brehob and F. H. Craton, General Electric Co.

Motors for 3,000-Volt D-C. Multiple Unit Cars, J. C. Aydelott, General Electric Co.

The Temperature Rise of Ventilated Railway Motor Armatures, D. A. Lightband, Westinghouse Elec. & Mfg. Co.

*High Capacity Rectifier Efficiency Improved by Sectionalization, A. L. Atherton, Westinghouse Elec. & Mfg. Co.

*European Railway Electrification, W. S. Gordon, Jr., Railway Electrical Engineer, Montclair, N. J., and E. Jaboolian, formerly with Jackson & Moreland, Hoboken, N. J.

Friday—10:00 a. m.

L—Symposium on Time and Time Services

†Astronomical Aspects of Time, E. W. Brown, Yale University

*Modern Developments in High Precision Clocks, A. L. Loomis, Loomis Laboratories, and W. A. Marrison, Bell Telephone Laboratories, Inc.

*The Time Service of the U. S. Naval Observatory, J. F. Hellweg, U. S. Naval Observatory

*Time Services of the Telegraph Companies, G. W. Jansen, Western Union Telegraph Co.

*Time Services of the Power Companies, H. E. Warren, Warren Telechron Co.

Friday—2:00 p. m.

M—Communication

†New Key West-Havana Carrier Telephone Cable, H. A. Affel, American Tel. & Tel. Co., W. S. Gorton and R. W. Chestnut, Bell Telephone Laboratories, Inc.

†The Development of a Hand Set for Telephone Stations, W. C. Jones, Bell Telephone Laboratories, Inc.

†An Automatic Concentration Unit for Printing Telegraph Circuits, G. S. Vernam, International Communications Laboratories, Inc.

†Direct Printing Over Long Non-Loaded Submarine Telegraph Cables, M. H. Woodward, and A. F. Connery, International Communications Laboratories, Inc.

†Carrier Applications to a Telegraph Plant, R. E. Smith and L. A. Kelley, International Communications Laboratories, Inc.

†Direct Solutions of Coupled Tuned Circuits, L. A. Kelley, International Communications Laboratories, Inc.

N—Electric Welding

Forces of Electric Origin in the Iron Arc—An Explanation of Overhead Welding, F. Creedy, R. O. Lerch, P. W. Seal and E. P. Sordon, Lehigh University.

*An Improved A-C. Arc Welder, A. M. Candy, Westinghouse Elec. & Mfg. Co.

*The Fundamentals of the Design of Arc Welding Generators, K. L. Hansen, K. L. Hansen Engineering Co., Inc.

---

*These papers are under consideration for presentation at the winter convention, but up to the date of going to press, November 23, they have not been officially placed upon the program.

†These papers will not be published in advance form by the Institute but copies may be made available by the respective authors.

Kansas City District Meeting Well Attended

WITH a total registered attendance of 411 persons the South West District meeting held in Kansas City, Mo., October 22-24, 1931, was particularly noteworthy in the very active participation of Enrolled Students. The final tally of official registration showed 159 Members, 60 men guests, 19 women guests, and 173 students. All six of the District Sections—Dallas, Houston, Kansas City, Oklahoma City, St. Louis, San Antonio—were represented, as were also practically all of the District's fourteen Student Branches.

Although evening and Saturday sessions usually are not crowned with success, the two such sessions held at Kansas City were unquestionably successful if attendance may be taken as an index. Of the four technical sessions the Thursday afternoon and Saturday morning sessions were held in the roof garden ballroom of the Kansas City Athletic Club, while the Thursday evening and Friday morning sessions were held in the beautiful Thomas Alva Edison memorial auditorium in the new office building of the Kansas City Power and Light Company. The evening session in the power company's auditorium was in the nature of a public meeting featuring various angles of the St. Louis-Bagnell interconnection, supplemented by motion pictures of Bagnell Dam and powerhouse, and of the 129-mile "Lake of the Ozarks" created by the dam.

Opening Addresses

With A. E. Bettis, past vice-president (1926-28) as chairman, Dean G. C. Shaad, gave the opening address following the official welcome extended by Col. R. D. Garrett for Kansas City's Mayor, Bryce B. Smith. In his presentation Dean Shaad described the fundamentals of the Institute organization and the reasons underlying the promotion of District meeting activities. He pointed with some pride to the 12.5 per cent growth in Institute membership that has occurred in District 7 for the Institute year recently closed, and commended the District's newer and smaller sections for their active development work.

President C. E. Skinner in addressing the gathering expressed himself as also believing that the "future of engineering students is very bright indeed," pointing out with some emphasis the fact that electrical engineering graduates now are occupied in gainful pursuits in percentages higher than any other class of graduates. Doctor Skinner urged careful stock taking and careful planning for the future during the present period of business unrest, and urged a realization of the cyclic character of the situation. He read a report issued by the United States Secretary of Labor some 47 years ago which specifically made the prediction that (then) "the needs of the world now are more than adequately provided for and it is useless to look to the future for further large developments or profits." Doctor Skinner reviewed very briefly the advancements made in the ensuing 47 years stating that they should be index enough of what can happen during the next period of similar length.

National Secretary F. L. Hutchinson also spoke, emphasizing briefly the need of more constructive attention to the matter of technical advancement and less attention to such current non-productive phrases as "technological unemployment." Mr. Hutchinson pointed out that technical advancement inevitably provides for increases in employment and general productive activities which otherwise never would develop. As one specific example he cited the contributions of Thomas A. Edison, whose work has provided the basis for tremendous industrial activity employing hundreds of thousands of individuals.

Edison Memorial Program

To present a short Thomas A. Edison memorial program Chairman Bettis called upon two Edison Pioneers to speak briefly. Joseph F. Porter (M'87 and Member for Life) president of the Kansas City Power and Light Company, cited the difficulties with which Edison was faced in the early development and promotion of his ideas, calling attention to the value of reverses which necessitate close application to the work in hand. Bringing his reasoning down to date, he urged diligent individual application as an important means of overcoming the present economic disturbance. As a bit of interesting history he mentioned the fact that on November 14, 1881, agreements were signed with Thomas A. Edison giving L. K. Moore and Joseph Chick the right to use in Kansas City patented rights, machines, and associated power plant equipment, resulting in the completion in 1882 of Kansas City's first electric generating plant. William Hahn, Kansas City manager for the General Electric Company, described the basis on which the organization of Edison Pioneers was built and quoted their official aims. Concerning an everlasting memorial to Thomas A. Edison, Mr. Hahn said that "the electric industry is a true and everlasting monument to Edison."

Student Sessions

Two student sessions were held the first day of the meeting at which the following ten papers were presented:

Modulation by Means of a Class B Amplifier, H. D. Labrecht, University of Arkansas.

Michael Faraday—The Man, C. M. Brecheisen, University of Kansas.

Choice of Equipment for Petroleum Pump Stations, V. J. Sittel, Oklahoma A. & M. College.

Accumulation of High Potential Static Charges on Transmission Lines During Sand Storms, C. E. Houston, Texas Technological College.

Sound as Applied to Synchronized Talking Pictures, M. R. James, Missouri School of Mines and Metallurgy.

A Synchronous Contactor in Transient Study, S. P. Robertson, University of Texas.

Control of the Hot-Cathode Thyratron, J. V. Melton, Southern Methodist University.

Design and Construction of Radio Field Intensity Measuring Equipment, G. S. Hammonds, University of Oklahoma.

Carrier Current Communication Over High Voltage Power Lines, J. E. Shepherd, University of Missouri.

Television, W. R. Mitchell, Kansas State College.

Main Sessions

Of the four main sessions, two were devoted to transmission and distribution problems, one to communication, and one, as mentioned, to the St. Louis-Bagnell interconnection. Session chairmen were: D. D. Clarke (M'18) of the Kansas City Section, and District Vice-President G. C. Shaad (F'13) respectively for the two transmission and distribution sessions; Stanley Stokes (F'29) of the St. Louis Section, for the interconnection session; E. T. Mahood (M'28) of the Kansas City Section, for the communication session. All of the eighteen technical papers presented at the four sessions and not previously or contemporarily published in Electrical Engineering in comprehensive form were abstracted on p. 900-3 of Electrical Engineering for November 1931 and hence will not be discussed further here. Papers of both local and general interest were presented. All were well received and actively discussed, although the paucity of written discussion precludes the usual publication of a summarized review of discussion.

Entertainment

Under the influence a very evident air of spontaneous western hospitality, the social functions, staged under the direction of the local committees, were among the most wholly successful social affairs held this year in connection with major Institute meetings. Local sightseeing trips and inspection trips of a technical nature were available in wide variety; for the women there was a bridge luncheon, several excursions and other enjoyable activities; for those who wanted golf facilities, these were provided also. A dinner dance featuring particularly well planned entertainment and held in the grand ballroom of the Kansas City Athletic Club Friday evening proved a fitting climax for the social activities held in connection with the District meeting. A much appreciated part of the evening's program was the total omission of all speakers.

District 7 Executive Committee Convenes at Kansas City

During the recent District meeting in Kansas City, Mo., a meeting of the executive committee of the Institute's South West District was held on October 23, 1931. Present were: chairman and District vice-president, G. C. Shaad (Lawrence, Kans.); District secretary, R. W. Warner (Lawrence, Kans.); Section chairmen, G. A. Dyer (Dallas, Texas); E. M. Wise (Houston, Texas); George Fiske (Kansas City, Mo.); C. T. Almquist (Norman, Okla.); C. H. Kraft (St. Louis, Mo.); J. E. Woods (San Antonio, Texas); Section secretaries, S. M. Sharp (Dallas, Texas); J. S. Waters (Houston, Texas); R. M. Ryan (Kansas City, Mo.); C. E. Bathe (Oklahoma City, Okla.); C. H. Lankford (St. Louis, Mo.); acting Section secretary, I. A. Uhr (San Antonio, Texas); chairman of District committee on student activities, F. G. Tappan (Norman, Okla.).

In selecting a member to represent this District on the national nominating committee, C. T. Almquist (Norman, Okla.) was declared elected. A motion that Mr. Almquist go uninstructed was carried. G. A. Mills (Dallas, Texas) was nominated as candidate for the office of vice-president from the South West District to be voted upon at the coming spring election of officers. The following four additional members of the coordinating committee were elected: George Fiske (Kansas City, Mo.); S. M. Sharp (Dallas, Texas); C. H. Lankford (St. Louis, Mo.); and E. M. Wise (Houston, Texas). Also to serve on this committee W. L. Upson (St. Louis, Mo.) was elected from the student counselors.

Other matters of interest to the District were discussed, including the date and location of the next District meeting.

In the meeting of student counselors and student Branch chairmen, F. G. Tappen (Norman, Okla.) was elected to succeed W. P. Weinbach (Columbia, Mo.) as chairman of the District committee on student activities.

Directors Meet at Kansas City

A regular meeting of the Institute's board of directors was held at the Kansas City (Mo.) Athletic Club, Friday, October 23, 1931. Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Vice-Presidents*—H. P. Charlesworth, New York, N. Y.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; P. H. Patton, Omaha, Neb.; G. C. Shaad, Lawrence, Kans. *Directors*—A. E. Bettis, Kansas City, Mo.; B. D. Hull, Dallas, Tex.; J. E. Kearns, Chicago, Ill.; A. M. MacCutcheon, Cleveland, Ohio. *National Secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of August 4, 1931, were approved.

A minute in memory of Thomas A. Edison was adopted. (This minute was published in the November issue of ELECTRICAL ENGINEERING, p. 907.)

The board ratified actions taken by the executive committee, under date of September 28, 1931, on 46 applications for admission to the grade of Associate and five to the grade of Member; three for transfer to the grade of Member, and 35 for Student enrolment.

Reports of meetings of the board of examiners held September 23 and October 20, 1931, were presented and approved; upon the recommendation of that board, the following actions were taken on pending applications: 276 Students were enrolled; 59 applicants were elected to the grade of Associate and 12 to the grade of Member; 28 applicants were transferred to the grade of Member and two to the grade of Fellow.

Approval by the finance committee for payment of monthly bills amounting to $36,170.11 was ratified.

Upon the recommendation of the finance committee it was decided, because of present economic conditions, to omit the publication of a year book for 1932, and to suspend until further notice, payment of traveling expenses to provide for the Sections occasional addresses by prominent Institute members designated as "Institute lecturers."

A budget for the appropriation year of the Institute beginning October 1, 1931, submitted by the finance committee, was adopted.

Upon request of the executive committee of the North Eastern District, the board approved the dates May 4-7 for the 1932 District meeting to be held at Providence, R. I.

The following actions were taken upon the recommendation of the standards committee: "Standards for Metal Tank Mercury Arc Rectifiers" prepared by the sectional committee on mercury arc rectifiers, for which the Institute is sole sponsor, approved for submitting to the American Standards Association for approval as a tentative standard; a revision of paragraph 13-250 of A.I.E.E. Standard No. 13, "Transformers, Induction Regulators and Reactors," approved for submitting to the Electrical Standards Committee with the recommendation that it be incorporated in the revision of Standard No. 13 already submitted to that body.

Amendments to the by-laws were adopted canceling the name "Meetings and Papers Committee" wherever they occur in the by-laws and substituting "Technical Program Committee," and canceling the name "Law Committee" and substituting "Committee on Constitution and By-Laws."

Section 71 of the by-laws, relating to the functions of the law committee, was canceled and the following was substituted:

> Sec. 71. The committee on constitution and by-laws shall consist of five members and shall consider all matters relating to the constitution and by-laws of the Institute, including the legal status in connection therewith, also all other matters referred to it by the board of directors, the president, or the national secretary. The committee shall make reports and recommendations to the board of directors for action thereon and may consult legal and technical counsel with reference to any question before it.

A new section of the by-laws was adopted, as follows:

> Sec.—The committee on legislation affecting the engineering profession shall consist of fifteen members. It shall consider all matters relating to existing or proposed legislation which has an engineering content, and which concerns the welfare of the public or the practise of professional engineering. The committee shall also consider and report upon all other matters referred to it by the board of directors, the president, or the national secretary, and may consult legal counsel with reference to any question before it.

Upon the recommendation of the committee on economic status of the engineer a resolution was adopted urging Institute Sections to cooperate with other local groups of engineers in the organization of an engineers' unemployment relief committee in each community.

In accordance with the constitution and by-laws, the following five members of the board of directors were selected to serve on the national nominating committee: A. B. Cooper, B. D. Hull, W. B. Kouwenhoven, A. M. MacCutcheon, and C. E. Stephens.

The board confirmed the appointment by the president of P. M. Lincoln as a member of the Lamme Medal committee to fill a vacancy.

F. D. Newbury was reappointed a representative of the Institute on the Standards council of the American Standards Association for the three-year term beginning January 1, 1932; and H. H. Henline, A. M. MacCutcheon, and H. S. Osborne were appointed alternates for the year 1932. H. S. Osborne was appointed to act as alternate for any of the A.I.E.E. representatives on the Electrical Standards Committee. V. J. F. Brain, chief electrical engineer, Department of Public Works, Sydney, N.S.W., was appointed local honorary secretary of the Institute for Australia, to succeed H. W. Flashman, who is no longer located in Australia.

The following resolution was adopted in appreciation of the fourth gift to Engineering Foundation by Ambrose Swasey:

Whereas, Dr. Ambrose Swasey, Honorary Member of the A.I.E.E., has recently presented an additional fund of $250,000 to Engineering Foundation, which was founded in 1915 as a result of his vision and leadership, and to which he has now contributed a total of three-quarters of a million dollars for "the furtherance of research in science and engineering, or the advancement in any other manner of the profession of engineering, and the good of mankind," be it therefore

Resolved: That the board of directors of the American Institute of Electrical Engineers hereby expresses its deepest appreciation of Doctor Swasey's recent gift, a generous provision for the extension of the activities of the Foundation, and an admirable expression of his continuing faith in the importance of its accomplishments as well as its promise of even more important future contributions to the development of science and engineering.

The following resolution was adopted:

Resolved: That the board of directors hereby expresses its hearty appreciation of the effective services of the members of the District Meeting committee and its various subcommittees in arranging and carrying out, with gratifying success, the plans for the South West District meeting held in Kansas City, October 22-24, 1931.

Other matters were discussed, reference to which may be found in this and future issues of Electrical Engineering.

Unemployment Relief Plans Well Under Way

The following resolution, recommended by the A.I.E.E. committee on the economic status of the engineer, was unanimously adopted by the board of directors of the Institute at a meeting held in Kansas City, Mo., Oct. 23, 1931:

Whereas, it is desirable that the Institute cooperate in every movement that is already in progress to promote employment, and also to initiate within local communities a program that will contribute toward the relief of unemployed engineers;

Resolved: That this board recommends that each Section formulate and carry out a plan embodying substantially the following features:

1. The organization in each locality of a committee of engineers, preferably composed of representatives of all the engineering groups in the community.
2. This committee to collect and administer funds for purposes of loans and remuneration to deserving unemployed engineers.
3. A survey of the local engineers who are unemployed and in need of relief.
4. A survey of local opportunities for constructive work or employment, in which there may be utilized the services of the much larger group of unemployed, in addition to engineers; supported through the use of the community unemployment fund.
5. The preparation by the committee, by the aid of unemployed engineers as far as practicable, of engineering analyses, estimates, and organization requirements for such projects or work as the committee may endorse.
6. A forceful presentation by the engineers' committee of these projects to those in charge of the local civic unemployment activities, and the enlistment of their approval and financial support in promptly getting work started.
7. In carrying out the plan, each local Section of the Institute should work in close cooperation with local Sections of other national societies and with other local engineering groups; and, also, the general engineers' committee so organized should work in close cooperation with other local civic relief organizations.
8. In order that this plan shall be effective, it is essential that the local engineers' committees be carefully organized. A suggestion for such an engineers' unemployment committee is that it include some of the unemployed engineers, some good solicitors of funds, some good searchers for jobs, and some good organizers and administrators; and it is recommended that each committee have a chairman, a vice-chairman, a secretary, and treasurer, an executive committee to coordinate the work, a committee to administer the funds, make loans, arrange for remuneration to some of the unemployed engineers, etc., etc.
9. Each Institute Section is requested to keep the national committee on economic status of the engineer advised, through national headquarters in New York, as to progress and results obtained. The national committee, in turn, will endeavor to be of such aid as may be feasible.

It is the hope of the board that each Section will proceed, by cooperation with other sections of national societies and local engineering societies, if any, to organize in each community a single engineers' unemployment relief committee in accordance with the plan as outlined in the resolutions. To be effective, this program in behalf of unemployed engineers should be taken up vigorously and at once. Cities already organized in substantial accord with this resolution include Boston, Mass.; Chicago, Ill.; San Francisco, Calif.; and Toledo, Ohio.

In the metropolitan area of New York City, the American Society of Civil Engineers instigated activities to relieve unemployment. The Professional Engineers Committee on Unemployment Relief then was formed on the proposal of the A.S.C.E. that the four Founder Societies form a joint body to cope with the acute situation resulting from the large numbers of persons involved in that section.

The function of this committee is to find employment for professional engineers and to give financial aid to those actually in need. It is headed by H. deB. Parsons as chairman, and functions through an executive committee of which J. P. H. Perry is chairman, a financial committee with H. A. Kidder (F'29) as chairman, and a relief committee under the chairmanship of G. L. Lucas. Headquarters are in the Engineering Societies Building at 29 West 39th Street. Many members of the four engineering societies concerned are giving their personal time to the various phases of activity. Funds are being solicited for immediate relief and members are asked to help locate work for those still unemployed. A mass meeting attended by more than 800 engineers was held November 9 to acquaint members with the details of the plan and to inspire immediate action.

Faraday Centenary Meeting Well Attended

The memory of Michael Faraday was honored at a meeting held in the auditorium of the Engineering Societies Building, New York, N. Y., November 18, 1931. This meeting was under the auspices of the New York Museum of Science and Industry and was attended by about 700 persons.

Frederic B. Pratt, president of the museum, opened the meeting and called upon Dr. F. B. Jewett (F'12) to preside. Addresses were given by Prof. D. C. Jackson (F'12) head of the electrical engineering department of the Massachusetts Institute of Technology and Dr. Elihu Thomson (F'13-HM'28) director of research of the Thomson Laboratories of the General Electric Company. The subject of these addresses was the life and work of Michael Faraday. The meeting was arranged by the Faraday centenary committee of the museum, which consists of F. B. Jewett, chairman, G. F. Kunz, L. F. Loree, F. B. Pratt, C. W. Rice (F'12) C. R. Richards (M'24) M. S. Sloan (F'30) Frank A. Vanderlip, and Felix M. Warburg.

Standards

Mercury Arc Rectifiers

At the October 6th meeting of the A.I.E.E. standards committee, the report of the sectional committee on mercury arc rectifiers was received. This sectional committee, working under the rules of procedure of the American Standards Association and sponsored by the Institute, points out in its report that it appeared unwise to attempt to formulate rigid standards at this time.

After designs become fixed and greater operating experience is obtained, standards of a more rigid character will be made. The sectional committee found it necessary also to depart from the original set scope, and to confine its attention to metal tank rectifiers. There was no evident demand for standards for other types. The standards committee recommended to the board of directors the approval of the Institute as sponsor of the report. This approval was given on October 23, 1931. Upon final approval by the American Standards Association, this standard will become available in pamphlet form. Due notice will be given in a later issue of ELECTRICAL ENGINEERING.

Sound Measurement Committee Authorized

Following the Symposium on Noise presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931, recommendations were made to the board of directors that an Institute committee be appointed to cooperate with existing similar committees of several other organizations to develop uniform and practical standards for noise measurement. The matter was referred to the standards committee and at its October 6th meeting Chairman MacCutcheon was authorized to appoint the necessary contacting committee. Completion of the committee personnel is expected shortly, when work will get under way.

School Lighting Code Under Revision

The Illuminating Engineering Society has just issued in reprint form a revision of the Code of Lighting School Buildings prepared under the joint sponsorship of the Illuminating Engineering Society and the American Institute of Architects and adopted June 16, 1924, as an American standard under the procedure of the American Standards Association.

In this proposed new edition the primary purpose has been to establish criteria of good illumination for the guidance of architects, engineers, school officials, and others interested in the conservation of children's vision and the well-being and efficiency of both pupils and teachers.

This revision is now subject to approval by the sectional committee, the sponsors, and the American Standards Association, after which it will become available in pamphlet form. Inquiries and suggestions should be addressed to American Standards Association, 29 West 39th Street, New York, N. Y.

Engineering Foundation

Progress Discussed at Recent Meeting

The October 22nd, 1931 meeting of The Engineering Foundation has been characterized as one of the most progressive yet held. A study of the present industrial system, as proposed by H. V. Coes of The American Society of Mechanical Engineers, the research activities and procedures of the Founder societies, and a new statement of the policy and program of the Foundation, were the principal subjects of the evening.

Two new members were announced: G. W. Fuller, consulting engineer, New York, N. Y., nominated by the American Society of Civil Engineers to succeed W. H. Burr, resigned; and G. G. Crawford, president of the Jones & Laughlin Steel Corporation, member-at-large, to succeed Alva C. Dinkey (A'97) deceased.

By invitation two members of each Founder society's main research committee discussed with the Foundation board a proposal made to the Foundation by the endowment methods committee of the United Engineering Trustees, for the establishment of a research procedure committee to aid the Foundation in ascertaining the research needs of the Founder societies and in making the best use of available resources for aiding the research activities of these societies. There were present from the civil engineers committee, Chairman C. T. Morris, professor of structural engineering, Ohio State University, Columbus, Ohio, and T. Merriman, chief engineer, Board of Water Supply, New York, N. Y.; from the mining engineers, F. F. Colcord, vice-president U.S.S. Lead Refinery, Inc. and F. E. Pierce, consulting engineer, New York, N. Y.; from the mechanical engineers, A. D. Bailey, superintendent of generating stations, Commonwealth Edison Company, Chicago, Ill., W. H. Fulweiler, chemical engineer, United Gas Improvement Company, Philadelphia, Pa., and C. B. Le Page, secretary of the committee; from the electrical engineers, H. D. Arnold (F'29) director of research, Bell Telephone Laboratories, New York, N. Y., and L. W. Chubb (F'21) director of Westinghouse Research Laboratories, Pittsburgh, Pa.

Interesting differences in the research policies, needs, methods and activities of the societies were brought out by the members of their respective committees. After discussion, there was endorsed unanimously the proposal for a research procedure committee attached to the Foundation, this committee to include one member from each Founder society annually selected from, or designated by, its main research committee, with two members from the Foundation board. The recommendation has been submitted to the boards of the Founder societies.

American Engineering Council

A.E.C. Plans Unemployment Relief

Plans to mobilize the nation's engineers behind President Hoover's program to end the depression were announced recently by the American Engineering Council. The Council will work with the relief organization already set up under the leadership of W. S. Gifford (A'16) president of the American Telephone and Telegraph Company, with an aim toward not only promoting emergency measures but also toward the development of sound, permanent employment policies throughout American industry.

A national committee has been appointed by the Council to direct the engineering efforts which will be carried out in detail by additional committees being named in each state. F. J. Chesterman (F'22) vice-president and general manager, The Bell Telephone Company of Pennsylvania, Pittsburgh, Pa., has been named chairman of the national committee with other members as follows:

Gen. R. C. Marshall, Jr. (M'19) vice-president in charge, B-W Construction Company, New York, N. Y. (in charge of construction division of the War Department during the World War); E. K. Ruth, American Oak Leather Company, Cincinnati, Ohio; W. R. Webster, Bridgeport Brass Company, Bridgeport, Conn.; and L. W. Wallace, executive secretary, American Engineering Council, Washington, D. C.

In a number of states, committees are already at work under the following chairmen: C. E. Rose (A'27) Little Rock, Ark.; F. C. Carstarphen, Denver, Colo.; Henry Robinson Buck, Hartford, Conn.; R. W. Prince, (M'30) Dist. of Columbia; Melvin Price, Gainesville, Fla.; R. F. Schuchardt (F'12 and past-president) Chicago, Ill.; Frank D. Paine, Ames, Iowa; Carl Schneider, New Orleans La.; Paul Cloke (M'13) Orono, Maine; F. A. Allner (M'14) Baltimore, Md.; J. P. Hallihan, Detroit, Mich.; Paul Doty (M'12) St. Paul, Minn.; W. M. Cobleigh, Bozeman, Mont.; O. J. Ferguson (F'13) Lincoln, Neb.; George W. Cas , Durham, N. H.; C. A. Mees, Charlotte, N. C.; D. C. Henny, Portland, Ore.; F. F. Schauer, Pittsburgh, Pa.; R. W. Herrick (A'28) Providence, R. I.; J. A. McPherson, Greenville, S. C.; Mark Eldredge (M'20) Memphis, Tenn.; George A. Reed, Montpelier, Vt.; E. B. Norris, Blacksburg, Va.; and Joseph Jacobs, Seattle, Wash. Additional state chairmen are: G. M. Butler, Tucson, Ariz.; H. W. Hitchcock (M'27) Los Angeles, Calif.; R. A. Seaton, Manhattan, Kansas; Col. E. M. Stayton, Independence, Mo.; L. J. Bevan, Montclair, N. J.

DEFINITE PLANS MADE

In a recent report by the committee it was stated most emphatically that "the immediate answer for unemployment is jobs; . . . the spreading of man-hours is the most essential expedient for stabilizing employment that can be suggested at the present time; . . . plans should be started immediately. . . toward lightening the consequences of any further or future unemployment." In line with these stipulations, the committee outlined a comprehensive program under which engineers individually and collectively can develop helpful measures of correction by carefully studying the problem in their respective employment areas.

It is planned to place special emphasis on the study of all proposed or active government projects, and to inform the public or take other action to insure construction being carried out properly and expeditiously. Attention will be devoted also to the development of a future plan to assist in stabilizing industry.

Board of A.E.C. Holds Fall Meeting

The fall meeting of the administrative board of the American Engineering Council held in Washington, D. C., October 30-31, 1931, devoted the full two days to a discussion of numerous problems important to the engineering profession. Among these matters, the progress report of the public affairs subcommittee was presented. The committee is of the opinion that there is urgent need for a general survey of conditions surrounding the transportation of persons and of property in interstate commerce. This survey has been proposed by congressional legislation. It is felt that this investigation should be made not by the Interstate Commerce Commission alone but by a body consisting also of men prominent in the government, and federal reserve system, as well as by representatives of railroads and shippers.

The administrative board adopted a policy relative to legislation concerning rivers and harbors, to the effect that legislation on all unapproved projects should be checked and reported to the committee of public affairs which would determine what action should be taken.

The board also voted to form a special committee to consider the intelligent integration of industry with agriculture not only as an emergency measure, but also as a possibility for future advancement.

St. Lawrence Project Reviewed

At its meeting, January 1931, American Engineering Council voted to appoint a committee to review the economic aspects of the report of the Institute of Economics, made by H. G. Moulton, C. S. Morgan, and A. L. Lee and entitled "The St. Lawrence Navigation and Power Project." C. E. Grunsky, Jr. and E. L. Grunsky were selected to undertake this work.

In this latter report which has just been rendered to American Engineering Council, Messrs. Grunsky found a number of instances in which they questioned the conclusions of the authors of the book.

A copy of the report prepared by C. E. Grunsky, Jr. and E. L. Grunsky may be had upon application to American Engineering Council.

Letters to the Editor

Mr. Edison's Greatest Work

To the Editor:

"A filament of carbon of high resistance" enclosed in a vacuum bulb hermetically sealed—the basis of his first demonstration in 1879 and of the foundation patent in 1880—with the collateral central station developments, around these will finally be written the Edison saga, for, regardless of the importance of his other inventions, the development and mastery of electric lighting by incandescence was Mr. Edison's most dramatic and difficult work, and its influence upon the modern electric age his most far-reaching one.

He did not originate the broad idea of parallel circuit distribution, or of getting light from an incandescent filament and enclosing it in a container, or even the use of carbon, but he was without question the creator of that type of construction which made possible his ideals of an individuality of use analogous to that provided in the existing gas, water and steam systems. To that objective he clung with extraordinary tenacity and courage over a long period beset with many failures and innumerable difficulties, and in the face of ridicule and a nearly unanimous opinion that the end he sought was unattainable.

As a juror at the Crystal Palace Exhibition in Suydenham in 1882, and in charge of special tests, I had an exceptional opportunity for first-hand knowledge, and my conclusions were voiced in a report made to the U. S. Navy Department in 1883, in the following words:

"In the matter of making the transmission of light and power a practical success, in bringing it home to every-day domestic economy, Mr. Edison, without doubt, has done more than all others, and while his system is by no means yet perfect it is unquestionably far ahead of the work of anyone else."

Mr. Edison was the apostle of a universal direct-current supply from central stations at moderate potentials, despite the inevitable limitations, and his individual work in the lighting field, which was his main objective, practically reached its climax in the middle '80's, when he announced his intention to develop "a new crop of inventions," and in 1888 resumed work on the phonograph, invented some nine years earlier. A year later his electric enterprises were consolidated in the Edison General Electric Company, with resultant transfer of most of his responsibilities.

But already the great advances of the succeeding decade, collateral indeed but made by other men, had been initiated and were in full swing. The constant speed industrial motor had been adopted by the Edison Companies in 1885, and the pioneer work at Richmond had laid the foundation of the modern electric railway. The advent of the single and multiphase alternating circuit systems of transmission and conversion of energy at high potential had made possible the utilization of water powers, and with the later development of the steam turbine laid the only possible foundation of the great modern power plants. Soon came also multiple unit train control, vital to mass movements by electricity.

Carbon has now been replaced by its predecessor. th metallic filament; the vacuum, although it must first be got, is no longer a continuing essential; the gas lamp has opened new vistas of economy; and the alternating-current system has come into its own. But whatever the developments in the electric art and however wide the departures in practise, the vital fact remains that Mr. Edison established the first real central station for the general distribution of electricity, and his name has become a symbol for fertility of invention and untiring activity, with results which have made the world forever his debtor. He has indeed lighted the world.

Very truly yours,
FRANK J. SPRAGUE (F'12)
(Past-President of the A.I.E.E.
President, Sprague Safety Control
& Signal Corp., New York, N. Y.)

Engineering Progess—1731-1931

To the Editor:

Complying with the Engineering Foundation desire for engineers' comments on the article on "Engineering Progress 1731-1931," I would like to say that I think Martin J. Insull in his contribution in your September issue has brought up a subject of exceptional importance.

All engineers are convinced that engineering knowledge and skill in the aggregate has been of greatest benefit to Mankind. On the other hand, there are some changes which resulted from engineering achievements and their application that produced quite opposite results. Chief amongst these, in my opinion, has been the shrinkage in size and commercial activity of small towns.

There is, I believe, no question that small towns having populations of from 3,000 to 7,500 people form ideal social, political, and industrial units. That many such towns have reduced importance and even less population today (as a result of massing of manufacture in large cities) is painfully evident.

If Mr. Insull and his affiliated interest and several large manufacturing organizations could work together and demonstrate that Mr. Insull is right as to the possibility and practicability of decentralizing much of our congested manufacturing by distributing it into present or new towns of ideal size and location it would, in my opinion, be of tremendous value to all people.

Of course Mr. Insull is right when he says that under present conditions power can be delivered in any desired amount practically anywhere one would care to develop a town. By working with several large manufacturing corporations such towns could be established any desired distance apart. If only five or ten miles apart, much of the extra overhead expense of superintendence of a small plant need not be appreciably more than in larger plants, for many of their superintendents easily could take care of four or five small plants so located if they all belonged to one corporation. By having in each town plants belonging to two or more corporations the diversified industry that is so desirable would exist in each.

In many cases, by such cooperative effort, old towns could be brought back and above their old standing; but my recommendation would be to build in most cases entirely new and modern towns. If skill were used in finding the best and most attractive locations they could be developed into something far more attractive than the present average town.

When one sees the immense difference between the average small town and the few ideal towns we now have (for instance Dalton, Mass. as built up by the Crane family around their paper mills) it is easy to see that success will be more certain if carried out with "whole cloth."

Assuming the present average power consumption to be about 4 kw. per employee in manufacturing plants, there would be required in a town of 5,000 people, 2,000 of which were working in its factories, some 10,000 kw. of transformer capacity, including domestic requirements. This is enough power to be economical in cost of equipment even if the supply is taken direct from 110-kv. or even 220-kv. transmission lines. If the cost were considered too great at 220 kv., then substations of 20,000-kw. capacity could be used by placing them midway between towns and the power be distributed at from 2.4 to 6.6 kv. to towns on either side.

A little progress has been made already, as we all know, in decentralization of manufacture, but the progress is likely to continue to be slow unless some competent central body skillfully directs the movement.

I think it would be highly desirable therefore, for the Engineering Foundation to appoint a special committee to study Mr. Insull's proposition and show what great things could be accomplished by such an effort.

A committee representing the utilities companies the large manufacturing interests and the architects would seem to be what is needed.

What greater gift could this generation of engineers present to the generations that are to follow, than to arrange so that some ten million or more, who under present practice are doomed to live and work in the congestion of great cities, could work and live in some one of 2,000 such new and delightful small towns.

Very truly yours,
WALTER S. MOODY (A'06, F'12)
(Consulting Engineer, Transformer Departments, General Electric Company, Pittsfield, Mass.)

Personal

Doctor Whitehead to be Awarded Medal

Electrical World Photo

J. B. WHITEHEAD

John Boswell Whitehead (A'00-F'12 and Life Member) professor of electrical engineering and dean of the faculty of engineering, The Johns Hopkins University, Baltimore, Md., is to receive the Elliott Cresson Gold Medal to be awarded by the Franklin Institute on May 18, 1932. This medal is to be conferred "in consideration of his many original investigations of dielectric behavior and allied subjects." *The Journal of the Franklin Institute* gives the basis of this award as follows:

"This medal is awarded for discovery or original research, adding to the sum of human knowledge irrespective of commercial value; leading and practical utilizations of discovery; and invention, methods or products embodying substantial elements or leadership in their respective classes, or unusual skill or perfection in workmanship."

The particular work which lies back of this award is the great amount of research which Doctor Whitehead has carried on during the past eight or ten years in the field of the fundamental properties of dielectrics as related to the behavior of insulating materials. This has covered gaseous ionization in laminated insulation, dielectric absorption in simple and complex materials, properties of liquid dielectrics, particularly the insulating oils, and the relation of these properties to the behavior of impregnated paper as used for high voltage cables. Responsible in a large measure for the advances made is the development of experimental methods for measuring the charge and discharge currents of dielectrics under continuous potential for very short intervals of time following the application of voltage. These continuous voltage measurements have been correlated with alternating measurements so that from the measurements of short time continuous voltage, the behavior of dielectrics under stress may be predicted completely as regards dielectric loss, power factor, and capacitance.

Doctor Whitehead has been active in Institute affairs for many years. He was the founder of the Baltimore Section and for nineteen years served as its chairman. From 1924 to 1928 he was a member of the board of directors of the Institute. He has served as chairman of the electrophysics committee 1912-1916, chairman of the research committee 1923-1927, and at various times as a member of committees on research, electrophysics, electrochemistry, code of principles of professional conduct, education, technical activities, and others. Since its inception he has been identified with the work of the committee on research.

The Institute selected him as its representative on the division of engineering and industrial research of the National Research Council, and as its delegate to the Conference Internationale des Grand Reseaux Electriques, Paris, France, 1927. In connection with the former he served as chairman of the committee on electrical insulation.

Practically every year since 1910 Doctor Whitehead has presented to the Institute one or more papers the aggre-

C. W. RICE

gate of these numbering thirty-two. The Institute publications have been practically the sole medium of publication for his work.

Doctor Whitehead is a Fellow of the American Physical Society, and a Member of the Society for the Promotion of Engineering Education, the National Institute of Social Sciences, the Societe Francaise des Electriciens, and the National Research Council. He was exchange professor to France 1926-1927. Honors awarded him include the Edward Longstreth Medal of the Franklin Institute, 1917, the Triennial Prize of the Institute Elektrotechnique Montefiore Liege, Belgium, 1922 and 1925, and the medal of honor of the University of Nancy, France, 1927.

Calvin W. Rice Honored by A.S.M.E.

A ceremonial to be given prominence on the program of the annual dinner of the American Society of Mechanical Engineers to be held on the evening of Wednesday, December 2, 1931, will be the bestowal of honorary membership in the society upon its secretary Calvin W. Rice (F'12), who for the past twenty-five years has worked with untiring diligence for its advancement both nationally and internationally, professionally, educationally, and civically. His achievements are too well known to require detailed delineation here. For these achievements and because he is considered by his confrérès to typify the finest attributes of the engineer, Doctor Rice has been chosen for honorary membership in this organization. The address of presentation will be made by Dr. Karl T. Compton, president of Massachusetts Institute of Technology, Doctor Rice's alma mater. Dr. William F. Durand (M'20) past-president of the A.S.M.E. will preside over the events of the evening, auspicious in the history of the organization and including the bestowal of four 50-year Badges of Honor upon other veteran members of the Society.

W. H. Sawyer (F'13) recently elected chairman of the executive committee of the Iowa Public Service Company, Sioux City Gas & Electric Company, and the Sioux City Service Company, will devote a portion of his time to active supervision of these properties. but will continue his consultant and sponsorship activities at his New York office, 120 Broadway.

W. N. Clark (A'05) vice-president and general manager of the Southern Colorado Power Company, Pueblo, Colo. has now been elected its president. His vice-presidency dates from 1924, and his work was instrumental in bringing together into one organization four of the leading electric companies in the Cripple Creek mining district.

C. G. Jones (M'18) has been acting as inductive heating engineer for Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., but recently has resigned to become special engineer for the Youngstown Sheet and Tube Company, Youngstown, Ohio.

P. Trombetta (A'21) on the first of October resigned from the research laboratory of the A. O. Smith Corporation of Milwaukee, Wis., to organize The Solenoid Company for the manufacture of electrical machinery and protective devices of divers types.

F. A. Kolster (M'19) formerly chief research engineer for the Federal Telegraph Company, Palo Alto, Calif., removed recently to New York, N. Y., where he will assume new duties with the International Communication Laboratories, Inc.

P. R. Farrow (A'07) who prior to November 15, 1931 was resident engineer for the Kaministiquia Power Company, Ltd., Kakabeka Falls, Ont., Can., now is manager of operations for the Ontario Power Service Corporation, Fraserdale, Ont., Can.

C. E. Baxter (A'22) telegraph and telephone engineer of the New York Central Railroad Company, Grand Central Station, New York, N. Y., has removed to Detroit, Michigan, to continue these services for the company there.

R. H. Ballock (A'25) manufacturers representative of the Central Station Equipment, Tacoma, Wash., entered the government's employ and is senior engineering draftsman in the Navy Department, Bureau of Engineering, Washington D. C.

W. R. Swoish (A'29) who has been salesman in the central station section of the Westinghouse Electric and Manufacturing Company, Buffalo office, has been transferred to the distribution transformer section, Sharon, Pa., as manager.

N. D. Russell (A'24) who has been performing the duties of superintendent of service and technical inspection for Electrical Research Products, Incorporated, Dallas, Texas, now is at Columbus, Ohio, as engineer for this organization.

R. B. Tenney, Jr. (A'10) engineer of the Texas Power and Light Company, Dallas, Texas, recently has become consulting engineer at Dallas for the Power Cost Engineering and Appraisal Corporation, San Antonio, Texas.

M. J. Mallery (A'30) formerly lighting specialist for the Westinghouse Electric and Manufacturing Company, St. Louis, Mo., now has joined the Steam Equipment Company, Memphis, Tennessee, in the office of secretary.

D. S. Nicol (A'14) who heretofore has been associated with Parsons, Klapp, Brinckerhoff & Douglas, Detroit, Mich., entered the educational field as professor of electrical engineering at Nova Scotia Technical College, Halifax, N. S.

Herman Ulanet (A'30) who was superintendent of the Federal Steel Products Company, Newark, N. J., now has been elected president of the George Ulanet Company, engineers and manufacturers in Newark, N. J.

H. E. Hoadley (M'26) who has been serving the Ohio Public Service Company as its superintendent of distribution at Warren, Ohio, recently became engineer for the Empire District Electric Company, at Joplin, Mo.

D. B. Taylor (M'27) previously resident engineer, Albany district, New York Power and Light Corporation, Albany, N. Y., has taken over the superintendency of the Schenectady (N. Y.) district of that company.

S. F. M. Wilde (A'30) who has been occupied as engineer assistant for Johnson & Phillips, Charlton, London, England, recently made new connections with Kennedy & Donkin, Withington, Manchester, Eng.

R. M. Arnold (A'25) who was chief engineer of the radio division, United Air Cleaner Company, Chicago, Ill., now is chief engineer of the radio division of the Grigsby-Grunow Company also of Chicago.

P. F. Meigs (A'31) previously erecting engineer for the Bucyrus Erie Company, South Milwaukee, Wis., now is assistant instructor, department of electrical engineering, University of Kansas, Lawrence, Kans.

S. N. Bose (M'22) inspection engineer, Cazenovia Electric Company, Cazenovia, N. Y. has gone to India to be chief electrical engineer of the Tata Iron & Steel Company, Ltd., at Jamshedpur.

E. deRziha (A'11) heretofore chief engineer of Siemens-Schuckertwerke A. G., Berlin, Germany now is identified with Société Continentale D'Electricité in Alger, North Africa.

R. R. Law (A'31) for the next two years will engage in graduate work at The Harvard Engineering School, Cambridge, Mass. Mr. Law has removed recently from Ames, Ia.

R. M. Bayle (M'21) general engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., now is engineer for the Westinghouse company at Chicago, Ill.

H. F. Jefferson (M'19) removed from Seattle, Wash., recently to become test engineer for the Jackson Bell Company, manufacturers of radios, Los Angeles, Calif.

C. H. Suydam (M'29) planning engineer for the Federal Telegraph Company, Palo Alto, Calif., has been transferred recently to the company's Newark, N. J. office.

J. L. Merrill (M'19) electrical engineer, Philadelphia, Pa., has undertaken a consulting practise in Jackson Heights, Long Island, N. Y.

Obituary

L. T. Robinson Dies November Third

Lewis Taylor Robinson (A'04—F'12) engineer in charge of the general engineering laboratory of the General Electric Company, Schenectady, N. Y., died suddenly at his home in Schenectady, November 3, 1931. His death was attributed to heart attack. He was 63 years old having been born in Springfield, Mass. Mr. Robinson early evidenced a fondness for mechanics, later leaning toward electricity, which was then just coming into practical usage. About that time Lynn became headquarters for the Thomson-Houston Electric Company; two years after the plant was started and when Lewis Robinson was seventeen years old, he was engaged there by E. W. Rice, then plant superintendent. Later Prof. Elihu Thomson took him out of the plant and made him his office assistant. His aptitude made for rapid progress and within a short time he was in charge of the company's standardizing laboratory and the calibration of fine instruments; in 1891, in partnership with G. A. Whitmore, he established a laboratory for electrical testing and the calibration of instruments. This company under the name of Whitmore & Robinson continued until 1893; then Mr. Robinson joined what was then the Schuyler Electric Company, at Middletown, Conn., later acquired by the newly formed General Electric Company. A year later he engaged with the Central Electric Company at Lewisburg, Pa., where he remained until in 1896 he joined the General Electric Company at Schenectady and became one of its chief organizers.

L. T. ROBINSON

For more than twelve years Doctor Robinson has devoted himself generously to Institute activities including active participation in more than thirty-five important committee assignments, several dealing with intersociety and international technical affairs. Three times he served on the Institute's board, twice as vice-president (1916-18, 1920-21) and once as manager (1913-16). Indicative of the wide scope of his active participation, a few of his committee memberships are mentioned: meetings and papers 1910-19 (chairman 1914-18); constitutional revision 1912-13; professional conduct 1912-13; editing 1912-14 (chairman) and 1916-17; standards 1914-27 and 1929 (chairman 1919-20); Edison Medal 1914-16, 1917-30, 1931; Sections 1918-19; coordination 1920-21 (chairman); instruments and measurements 1924-27. He was chairman of the Schenectady, N. Y., Section for the year 1915-16. A great many important subcommittees, particularly those of the standards committee, also received the benefit of Doctor Robinson's advice and counsel, and several important committee and subcommittee reorganizations were engineered by him. As an authorized A.I.E.E. representative he participated in the joint conference which the Founder societies held to organize the American Engineering Council, 1921; the radio standardization conference, 1922; a special committee on international standards, 1926; and the American Standards Association Council, 1929.

Doctor Robinson was the holder of more than thirty patents covering a wide range of electrical apparatus. In 1904 as collaborator in the electrical exhibit of the General Electric Company he received a silver medal awarded by St. Louis exposition. In 1929 Union College (Schenectady, N. Y.) conferred upon him the honorary degree of Doctor of Science as "inventor, engineer, musician." Music was his chief diversion; he promoted, assisted, and sometimes acted as conductor of the General Electric orchestra, and was recognized in musical circles as an artist of noteworthy ability.

He was a member of the Society of Engineers of Eastern New York, the American Physical Society, the National Electric Light Association, the American Association for the Advancement of Science, National Electric Manufacturers' Association, the United States committee of the International Electrotechnical Commission, and the American Standards Association.

George Milton Ogle (M'27) manager of the power and industrial department of the National Electric Power Company, New York, N. Y., and well known for his research work with regard to the effects upon the human system of electric shock, died suddenly October 14, 1931. He was a native of Louisville, Ky., having been born there in 1888. In 1909 he became signal engineer for the Pennsylvania Railroad Company, two years later becoming chief draftsman for Heyward Brothers & Wakefield Company, at Wakefield, Mass.; in three years' time he advanced to the position of superintendent of power and machinery. Then he joined the Edison Electric Illuminating Company of Boston (Mass.) as commercial engineer, removing in 1916 to New York for similar services with the Edison Electric Illuminating Company of Brooklyn (New York). Two years later he became electrical and mechanical superintendent for the Massachusetts Chocolate Company of Boston, Mass., which was making a complete electrification of its Boston plant. As resident engineer of this company, Mr. Ogle then was given entire charge of the mechanical and electrical departments in the erection of a new million-dollar plant at Burlington, Vt. In April 1918, the Westinghouse Electric & Manufacturing Company chose him as general engineer at East Pittsburgh, Pa., where his work was principally in engineering for shipyards. He was appointed chief electrical engineer of the United States Shipping Board Emergency Fleet Corporation, and later held the same position with the Vulcan Iron Works, Inc., Jersey City, N. J. He then became power specialist for the General Electric Company, serving the company in both Schenectady and New York. In 1925 he was made consulting engineer for the General Engineering & Management Corporation, until joining the organization with which he was identified at the time of his death.

Cedric Samuel Anderson (A'21) electrical engineer of the Anaconda Wire & Cable Company, Hastings-on-Hudson, N. Y., and a postgraduate student at Columbia University, dropped dead as he was attending class there on the morning of November 13, 1931. He was 42 years of age, having been born at Boston, Mass., February 16, 1889. While practising engineering, he was studying for his master's degree. Mr. Anderson already held a degree of B.S. in E.E. conferred upon him by Massachusetts Institute of Technology in 1911, which was the year he joined the Telluride Power Company, at Telluride, Colo. Upon the consolidation of several companies to form the Western Colorado Power Company, he was appointed assistant to the general manager, three years later to be chosen as superintendent of the Clark Electric Power Company at Tooele, Utah. In 1919 he left this organization to become sales engineer for West Penn Power Company, Pittsburgh, Pa. soon to be requested to undertake the work of district superintendent; the following year he was promoted to power engineer. His removal to Hastings came subsequent to 1927, and rounded out an experience of twenty years of progressive engineering.

Isaac Newton Lewis (A'07) retired colonel of the United States Army, died suddenly of heart failure the afternoon of November 9, 1931, at Montclair, N. J., where he resided. He was 73 years old, his native city being Uniontown, Pa. Graduating with the West Point class of 1884, he pursued his military training by a course at the Graduate Torpedo School, Willetts Point, which he completed in 1886. Following this he was placed in charge of electrical installations at Fort Wadsworth, subsequently being given charge of the department of electricity, power and power transmission, U.S. Artillery School, Fort Monroe, Va. His inventive genius contributed many devices for both military and civil applications, among them, the Lewis portable, air-cooled machine gun, the first weapon to prove effective against zeppelins. While stationed at Fort Leavenworth, Kans. in 1888 he invented the first successful artillery range and position finder, a device which was accepted immediately by the War Department. He was a member of the American Association for the Advancement of Science, the Union League and the Lawyers Club of New York, the Army and Navy Club of Washington, D. C., the Montclair Athletic Club, and the Colonial Society of Montclair, N. J.

Charles Ernest Long (A'27) general electrician and hydroelectric power plant operator for the Puget Sound Power and Light Company's eastern district, Wenatchee, Wash., met his death October 11, 1931, in connection with a mine accident. Mr. Long, who was 45 years old, was born in Elkhorn, Manitoba, Canada. He served an apprenticeship with the Toronto General Light and Power Company, later starting an electrical contracting business of his own under the firm name of the Davidson Electric Company. In 1915 he enlisted with the 1st Pioneers of the Canadian Expeditionary Forces, electrical division, and in 1917 engaged with the Canadian National Railways, for the superintendency of all electrical construction west of Saskatoon. In 1925 he came to the United States from Alberta, Canada, being employed one year in Seattle as an electrician, and the following year taking up his work with the Puget Sound Light & Power Company Tumwater Canyon plant. Here he was employed until two years ago, when he was transferred to electrician at the Royal Development Company's mine, making his home at Leavenworth, Wash.

Jan D. Otten (A'90) electrical engineer, Amsterdam, Holland, and a Member for Life of the A.I.E.E., died in Amsterdam, September 29, 1931. Doctor Otten retired from active professional practise in 1926, the year in which he received his election to Member for Life. Some of his earliest engineering work was in affiliation with the general European office of the Thomson-Houston International Company, at Hamburg, where he was located at the time he joined the Institute as an Associate in 1890.

Local Meetings

District 1 Executive Committee Convenes at Schenectady

The fall meeting of the executive committee of the Institute's North Eastern District was held in Schenectady, N. Y., October 9, 1931. Present were: *chairman and District vice-president*, I. E. Moultrop (Boston, Mass.); *District secretary*, A. C. Stevens (Schenectady, N. Y.); *Section chairmen*, R. G. Warner (New Haven, Conn.); R. W. Graham (Buffalo, N. Y.); F. R. Finch (Pittsfield, Mass.); Wm. S. Maddocks (Providence, R. I.); F. C. Young (Rochester, N. Y.); R. A. Beekman (Schenectady, N. Y.); C. W. Henderson (Syracuse, N. Y.); *acting Section chairmen*, W. H. Colburn (Boston, Mass.); R. F. Chamberlain (Ithaca, N. Y.); H. A. Maxfield (Worcester, Mass.); *Section vice-chairman*, E. E. Johnson (Schenectady, N. Y.); *Section secretary* W. B. Hall (New Haven, Conn.). Also present by invitation were: *assistant national secretary*, H. H. Henline (New York, N. Y.); *past-vice-president*, H. M. Hobart (Schenectady, N. Y.); *Section committee chairman*, E. S. Lee (Schenectady, N. Y.).

Prof. R. G. Warner was elected to serve on the national nominating committee. J. A. Johnson, at present a director of the Institute, was unanimously nominated for District vice-president. In addition to the District vice-president, District secretary, and chairman of the Branch counselors executive committee, the following were nominated for membership on the District coordinating committee: R. G. Warner (New Haven, Conn.); R. W. Graham (Buffalo, N. Y.); J. P. McCann (Worcester, Mass.); and F. C. Young (Rochester, N. Y.).

After discussing the organization of the committee in charge of the 1932 District meeting at Providence, R. I., a motion was unanimously carried to the effect that the 1933 District meeting be held at Schenectady during the early part of May.

Competition between the students of the Pittsfield and Schenectady Sections and the interest which this competition created among the older as well as the younger men, was cited as increasing the interest in student activities. Various means of aiding students in their activities were discussed; among others was suggested that prizes might be offered for student papers, based on delivery and content. Before adjourning, Past Vice-president H. M. Hobart and Assistant National Secretary H. H. Henline expressed their appreciation of the meeting and commended the members for their activities.

District 5 Executive Committee Meets at Chicago

The annual meeting of the executive committee of the Institute's Great Lakes District was held in the rooms of the Western Society of Engineers, Chicago, Ill., on Monday, October 12, 1931. Present were: *president* and *District chairman*, T. N. Lacy (Detroit, Mich.); *District secretary*, A. G. Dewars (Minneapolis, Minn.); *District treasurer*, K. A. Auty (Chicago, Ill.); *Section chairmen*, F. R. Innes (Chicago, Ill.); J. J. Shoemaker (Detroit, Mich.); E. J. Schaefer (Fort Wayne, Ind.); E. L. Carter (Indianapolis, Ind.); N. H. Blume (Madison, Wis.); C. H. Kreuger (Milwaukee, Wis.); Oscar Gaarden (Minneapolis, Minn.); E. H. Waldo (Urbana, Ill.); *Section secretaries*, O. E. Hauser (Detroit, Mich.); C. M. Summers (Fort Wayne, Ind.); E. G. Thoms (Indianapolis, Ind.); L. F. Wood (Des Moines, Iowa); G. F. Tracy (Madison, Wis.); E. V. Lassen (Milwaukee, Wis.); E. H. Hagensick (St. Paul, Minn.); E. A. Reid (Urbana, Ill.); *acting chairman*, C. L. Sampson (Des Moines, Ia.); *acting secretary*, R. D. Maxson (Chicago, Ill.); *District committee on student activities chairman*, G. C. Knipmeyer (Terre Haute, Ind.) Visitors were: *District convention committee vice-chairman*, F. A. Kartak (Milwaukee, Wis.); and *technical program subcommittee chairman*, J. F. H. Douglas (Milwaukee, Wis.).

K. A. Auty was unanimously reelected as District treasurer. Mr. Auty also was nominated for the post of vice-president of the Institute from the Great Lakes District (No. 5). T. N. Lacy was elected a member of the national nominating committee representing this District in the coming election for Institute president.

In addition to the vice-president, secretary, and chairman of the District committee on student activities, the following were elected to serve on the coordinating committee: C. H. Kreuger (Milwaukee, Wis.); N. H. Blume (Madison, Wis.); F. R. Innes (Chicago, Ill.); and E. V. Lassen (Milwaukee, Wis.). A motion was passed that the past coordinating committee continue to serve as a part of the District convention committee, assisted by the new coordinating committee. The report of the District convention committee was read and a motion was carried inviting the board of directors to meet in Milwaukee during the coming District convention. Reports of Section activities were also made.

Means of increasing the Institute's membership, as well as interest in Section meetings, were discussed. A motion was passed that a tentative program of Section meetings be prepared early in the season and circulated to all other Sections in the District.

Chicago Power Group Holds Season's First Meeting

The first meeting this season of the Chicago Section's Power Group was held October 22, 1931, in the Engineers Building, Chicago, in joint session with the Electrical Section of the Western Society of Engineers.

A brief introductory address by F. R. Innes, chairman of the Section, was followed by a discussion by P. B. Juhnke and A. R. Lake of the Commonwealth Edison Company before an audience of some 160 persons. The subject was "Power System Operation in the Chicago District." Mr. Juhnke dedicated the meeting to Mr. Edison whose early inventions had made the power industry possible; Mr. Lake described in detail some of the actual problems of interconnected system operation, demonstrating with the aid of charts and diagrams the subjects of telemetering, power flow control, frequency control, reserve capacity, etc. A recent case of trouble due to lightning on the overhead lines of the interconnected system was described illustrating the real effectiveness of reserve capacity for preserving continuity of service.

Future Section Meetings

Akron

December 8, 1931—Television, by J. O. Perrine, American Tel. & Tel. Co. Meeting to be held in the auditorium of the Firestone Tire & Rubber Co.

January 12, 1932—X-Ray Inspection of Welds, by Ancel St. John, president, St. John X-Ray Service Corp. Movies: "Story of Steel." Meeting to be held in the auditorium of the Ohio Edison Co.

Chicago

December 2, 1931—Short-Circuit Calculations and Application of Oil Circuit Breakers, by W. C. Hahn, General Electric Co.

January 7, 1932—Control of Noise and Vibration in Station Design, by P. E. Stevens, Byllesby Engineering and Management Corporation.

Cleveland

December 17, 1931—Behind the Scenes, by Dr. Zay Jeffries, metallurgical engineer and consultant; W. L. Enfield, manager, incandescent lamp development laboratory. Both of these speakers are with the General Electric Co. at Nela Park. Joint meeting with the Illuminating Engineering Society.

January 21, 1932—Some Institute Problems, by Dr. C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co.

Dallas

December 21, 1931—Social meeting.

January 18, 1932—General Developments of 1931. This subject will be covered by students of the Southern Methodist University Student Branch.

Detroit-Ann Arbor

December 1, 1931—Subject and speaker to be announced later. Meeting to be held at Detroit Edison Auditorium.

January 19, 1932—Ladies' night.

Lehigh Valley

December 11, 1931—Inspection trip to the central breaker of the Locust Summit District of the Philadelphia & Reading Coal & Iron Co. at 1:30 p. m. Dinner at the Necho Allen Hotel in Pottsville at 6:30 p. m. At 8 p. m. the following papers will be presented:

Electric Power in the Coal Fields and Its Application to Coal Mining, by W. H. Lesser, Penn Anthracite Mining Co.;

Field Tests of Circuit Breakers, by Prof. A. R. Miller, Lehigh University.

Louisville

December 18, 1931—The Engineer's Place in the Sun, by Prof. W. E. Freeman, University of Kentucky, and vice-president, Southern District No. 4, A.I.E.E.

January 22, 1932—Practical Application of Light Sensitive Cells, by J. U. Briesky, research engineer, Westinghouse Elec. & Mfg. Co.

Lynn

December 2, 1931—Ladies' night.

December 16, 1931—Lightning, by K. B. McEachron, General Electric Co.

January 6, 1932—Ladies' night.

January 16, 1932—Inspection trip to Loose Wiles Biscuit Co.

January 20, 1932—Local convention. Subject:—Centrifugal Air Compression.

Pittsburgh

December 8, 1931—Recent Developments in Electrical Research, by Dr. Phillips Thomas, research engineer, Westinghouse Elec. & Mfg. Co.

January 12, 1932—Some Institute Problems, by Dr. C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co.

Seattle

December 15, 1931—Rural Electrification Meeting. Papers by Prof. G. S. Smith, Washington State College; and H. J. Gille, manager, agricultural and industrial development, Puget Sound Power & Light Co. H. V. Carpenter, vice-president, North West District No. 9, A.I.E.E. will give a talk on Institute affairs.

January 19, 1932—Presentation of papers submitted for annual prize competition. Titles and speakers to be announced later.

Vancouver

December 7, 1931—The Design of the Modern Radio Receiver, by V. W. M. Fouracre, Northern Electric Co., Ltd.

January 4, 1932—Subject and speaker to be announced later.

Past Section Meetings

Baltimore

The Canal Situation, by J. F. Stevens, consulting engineer, former chief engineer of the Panama Canal (1905-07). Mr. Stevens discussed the economics of a supplementary route through Nicaragua and pointed out that from all statistics available the Panama Canal is of sufficient capacity to take care of all shipping requirements for years to come. Joint meeting with the A.S.C.E. and A.S.M.E. Sections, and Engineers Club. October 22. Attendance 150.

Chicago

Power System Operation in the Chicago District, by P. B. Juhnke and A. R. Lake, both of the Commonwealth Edison Co. October 22. Attendance 160. (A complete report of this meeting is published in this issue under "Local Meetings" p. 982.)

Cleveland

In the afternoon, members and guests assembled at the dock of the "U.S.S. Akron" where an interesting lecture was given by one of the guides who described the dock and dirigible. Following this lecture, those present went to the laboratories of the Ohio Insulator Company where opportunity was afforded to inspect insulators of recent design. In the evening W. T. Van Orman, Goodyear Zeppelin Corp., spoke on Developments of Lighter-than-Air Craft. A. O. Austin, Ohio Insulator Co., gave a series of demonstration illustrative of new developments in high voltage phenomena. Joint meeting with the Akron Section. Members of the Cleveland Engineering Society invited. October 8. Attendance 376.

The Navigation of the Akron, by Lieut.-Commander C. E. Rosendahl, captain of the "U.S.S. Akron." By the use of motion pictures, the evolution of airship construction was illustrated from that of the first crude ship built by Count Zeppelin to that of the Akron. Joint meeting with the Cleveland Engineering Society and the Akron Section. October 13. Attendance 1,500.

Columbus

Television, Its Fundamental Physical and Psychological Principles, by J. O. Perrine, American Tel. & Tel. Co. This lecture was accompanied by demonstrations of the types of apparatus used in television. October 27. Attendance 154.

Connecticut

The Fundamentals of Radio Broadcasting, by Prof. W. J. Williams, Rensselaer Polytechnic Institute;

The Requirements of Radio Broadcasting on Communication Circuits, by H. W. Sundius, Southern New England Telephone Co. Following these talks there was an inspection of the WTIC studios in the Travelers Building and of the transmitter on Avon Mountain. October 28. Attendance 300.

Dallas

Construction of the Hamilton Dam on the Colorado River in Texas, by F. A. Dale, Emery, Peck & Rockwood Development Co. October 19. Attendance 115.

Denver

Some Thoughts on Waves, by O. B. Blackwell, American Tel. & Tel. Co. Dean H. S. Evans and Prof. R. E. Nyswander, chairman, gave reports of the summer convention held at Asheville, N. C., last June. Joint meeting with the Telephone Pioneers of America and The American Bell Club. October 16. Attendance 75.

Detroit-Ann Arbor

Recent Developments in Electric Heating, by H. J. Hall and G. Coley, both of the Detroit Edison Co. Illustrated by slides. J. J. Shoemaker, chairman, gave a résumé of the District executive committee meeting held in Chicago. October 12. October 20. Attendance 80.

Erie

Development and Uses of the Modern Oscillograph, by A. D. MacAffer, General Electric Co. Many interesting tests made on the oscillograph were shown. October 20. Attendance 75.

Fort Wayne

Contact Potentials and the Theory of Dielectrics, by Dr. Karl Lark-Horovitz, Purdue University. Illustrated with slides and blackboard sketches. October 15. Attendance 75.

Houston

Effect of Wave Form on Operation of Induction Type Protective Relays, by P. H. Robinson, Houston Lighting and Power Co. Dinner preceded the meeting. October 29. Attendance 23.

Indianapolis-Lafayette

The Relation of Frequency and Quality in Communication, by J. L. Wayne and E. R. Moore, Indiana Bell Telephone Co. This talk brought out the importance of frequency requirements in the transmission of speech, music, and pictures. Demonstrations followed. Dinner preceded the meeting. October 16. Attendance 45.

Kansas City

Aims and Activities of the A.I.E.E., by Dean George C. Shaad, University of Kansas, and vice-president, South West District (No. 7) A.I.E.E. October 14. Attendance 54.

Building a Skyscraper, by G. O. Brown, Kansas City Power & Light Co.;

Conditions in Europe, by E. E. Howard, of Ash, Howard, Needles & Tammen;

Conquering the Missouri River, by Robert McDowell, student, A.I.E.E.

India, by Mundadhi Rau, student, A.S.M.E.

Joint meeting with the A.S.M.E. Section and the A.I.E.E. and A.S.M.E. Student Branches at the University of Kansas. November 5. Attendance 200.

Lehigh Valley

Inspection trip to the new hydroelectric project of the Safe Harbor Water Power Corp. October 3. Attendance 212.

Los Angeles

A Picture of Wave Motion, by O. B. Blackwell, American Tel. & Tel. Co. Illustrated with lantern slides. October 6. Attendance 103.

Louisville

Engineering Marching On, by Dean F. Paul Anderson, University of Kentucky. Short talk by Prof. W. E. Freeman, University of Kentucky, and vice-president, Southern District (No. 4,) A.I.E.E. October 30. Attendance 94.

Lynn

Three sound pictures were presented, "An Address by Dr. A. E. Kennelly, past-president of the A.I.E.E.," "Dr. W. D. Coolidge, Research Laboratory, General Electric Co., and his Cathode Ray Tubes," and "Mazda Lamps Preferred," followed by the serving of refreshments and an informal get-together of members present. October 21. Attendance 400.

Madison

Some Unique Electrical Heating Effects, by Prof. Edward Bennett, University of Wisconsin. Demonstrated. L. C. Larson, Section Delegate, gave a brief résumé of the 1931 summer convention held at Asheville, N. C. Dinner preceded the meeting. October 21. Attendance 45.

Memphis

Annual dinner meeting at which the following officers for the year 1931-32 were announced: W. A. Gentry, chairman; F. L. Christenbury, secretary; O. F. Long, treasurer, W. F. Bowld, M. Eldredge, and G. F. Leake, directors. Short talks by M. Eldredge, retiring chairman, W. A. Gentry, chairman, and W. R. Herstein, president, Memphis Chamber of Commerce. October 13. Attendance 40.

Minnesota

Electric Water Heating, by R. R. Herrmann, Northern States Power Co. Dinner preceded the meeting. October 28. Attendance 30.

Nebraska

Some Institute Problems, by Dr. C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co. Doctor Skinner showed several reels of motion pictures that he had taken on a recent world tour. Dinner preceded the meeting September 28. Attendance 180.

Niagara Frontier

The X-Ray in Industry, by E. W. Page, General Electric X-Ray Corporation. Illustrated by slides and motion pictures. Dinner in honor of the speaker was held at the Hotel Niagara. October 16. Attendance 85.

Philadelphia

Modern Long Distance Telephone Communication, by A. P. Godsho, Bell Telephone Co. of Pennsylvania. An active discussion followed the presentation of this paper. October 12. Attendance 75.

Pittsburgh

The Modern Engineer, by S. M. Kintner, Westinghouse Electric & Mfg. Co. Joint meeting with the Engineers Society of Western Pennsylvania. October 21. Attendance 140.

Portland

Ariel Hydroelectric Development, by G. Wisting and O. L. LeFever, both of the Northwestern Electric Co. Mr. Wisting spoke on the construction of the Ariel plant and showed slides of pictures taken during that period. Mr. LeFever outlined the electrical and hydraulic features of the development. October 20. Attendance 62.

Inspection trip to the Ariel Hydroelectric Development. October 24. Attendance 45.

Rochester

The Engineer as a Citizen, by Roy V. Wright, managing editor, *Railway Age*, and president, A.S.M.E. Interesting discussion followed the presentation of this paper. Joint meeting with the A.S.M.E. Section and Rochester Engineering Society. October 1. Attendance 128.

St. Louis

Some Institute Problems and the Electrical Industry, by Doctor C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. October 21. Attendance 65.

San Antonio

Army Air Corps Service, by Lieut. E. C. Lynch, instructor at Randolph Field. October 19. Attendance 37.

Saskatchewan

The Theory and Practise of Electrical Surveying, by Prof. T. Alty, University of Saskatchewan. Illustrated by slides. October 16. Attendance 22.

Seattle

The Engineer and the Community, by J. Frank McLaughlin, Puget Sound Power & Light Co. Annual dinner meeting. September 15. Attendance 86.

E. E. Fellows, General Electric Co., outlined problems which confronted the *Seattle Times* when it moved from a d-c. area to an a-c. area. K. L. Howe, Westinghouse Elec. & Mfg. Co., discussed the problem of maintaining the proper temperature of the molten metal in linotype machines. Wallace Quistorff, Puget Sound Power & Light Co., described the power supply arrangements for the *Seattle Times*. The meeting then adjourned to the Times Building for an inspection trip through the plant. October 20. Attendance 76.

Sharon

Simplified Practise and Standardization, by R. E. Hellmund, Westinghouse Elec. & Mfg. Co. November 3. Attendance 95.

Southern Virginia

Friday evening, October 30: Meeting opened with address of welcome by J. H. Berry, chairman. Motion pictures illustrating the four stages of power generation and the turbo-electric driven President Coolidge followed. Prof. W. S. Rodman, University of Virginia, introduced Dr. C. E. Skinner, president of the A.I.E.E. and assistant director of engineering, Westinghouse Electric & Mfg. Co., who spoke on Pioneers and Pioneering. Attendance 139.

Saturday, October 31: Murray J. Idail, manager of engineering, Virginia Public Service Co., described the new Bremo Bluff Plant of that company. An inspection trip to the Bremo Bluff Plant in the afternoon was preceded by luncheon at the William Frank Hotel in Fort Union, Va. Attendance 50.

Spokane

Inspection trip through the Fox Theater. The heating and ventilating system was described by the engineer in charge, and the projection and sound equipment, as well as the lighting effects, were described and demonstrated by operators in the projection booth. October 30. Attendance 55.

Springfield

Carrier Current Street Lighting Control, by Ralph E. Curtis, United Electric Light Co. Illustrated by slides. September 14. Attendance 52.

Welding, by Prof. C. A. Adams, Harvard University. October 13. Attendance 44.

Toledo

Underground Cable Practise, by F. L. Calvert, General Electric Co. October 16. Attendance 45.

Toronto

Waterwheel Governing, by A. Kalin, Woodward Governor Co. Interesting discussion followed. October 9. Attendance 105.

Surge Absorbers, by J. M. Thomson, Ferranti Electric, Ltd. Slides were shown illustrating absorbers used for the protection of meters, cables, and transformers, and the damage done to transformers by surge voltages. October 23. Attendance 111.

Urbana

Aladdin Up-To-Date, by H. D. Sanborn, General Electric Co. Illustrated by lantern slides describing some of the achievements of the research laboratory, with particular reference to the development of the vacuum tube. October 15. Attendance 80.

Business meeting. October 23. Attendance 11.

Utah

Relay Protection, by Felix Guenther, Utah Power & Light Co. Reports of the summer and Pacific Coast conventions were given by Prof. A. LeRoy Taylor, Dr. J. Hugh Hamilton, and Dr. H. T. Plumb. October 12. Attendance 47.

Vancouver

Particulars of Plant and Equipment on the Empress of Japan, by C. Hayden, chief electrician, "Empress of Japan." This meeting was held on board the Empress of Japan and those present inspected the ship at the conclusion of Mr. Hayden's address. October 5. Attendance 100.

The Lois River Power Development, by S. A. Perrot, S. A. Perrot & Co.;

Determination of Plant Efficiency Ruskin Generating Station, by C. W. Colvin, B. C. Electric Railway Co. Ltd. November 3. Attendance 62.

Washington

The Economic Activities of Russia, by Prof. D. O. Kinsman, Catholic University of America. Professor Kinsman described his experiences during a 5,000 mile trip through Russia. Dinner in honor of the speaker preceded the meeting. October 13. Attendance 125.

Worcester

Interesting Effects in Transformer Connections, by Prof. T. H. Morgan, Worcester Polytechnic Institute. October 22. Attendance 40.

Past Branch Meetings

University of Akron

Life of Michael Faraday, by Philip Syracopoulos, student. Frank Marcinkoski elected chairman. October 7. Attendance 19.

The Life of Charles Augustus Coulomb, by Daniel Coorsh, student;

The Principles of Television, by Harmon G. Shively, student. October 28. Attendance 11.

Alabama Polytechnic Institute

Smoker. Prof. W. W. Hill, counselor, gave a talk on the benefits of student enrolment in the Institute. September 17. Attendance 56.

T. E. Curtis, student, gave a report of the operation of the Georgia Power Company's plant near Atlanta. October 8. Attendance 15.

H. H. Altman, student, gave a talk on some of his experiences while employed at the N.B.C. studios in Chicago, Ill. W. H. Mims, chairman, outlined the inspection trip made by the senior students to several of the power plants of the Alabama Power Co. October 28. Attendance 11.

University of Alabama

Election of the following officers: Robert Lake, chairman; Fisher Allen, vice-chairman; Wood-Rowe Purcell, secretary; Irving Rosenblatt, treasurer. October 6. Attendance 11.

Film—"Insulated Wires and Cables." October 19. Attendance 34.

Armour Institute of Technology

Committee appointments announced. Talks were given by the officers to promote interest in the Branch activities. October 16. Attendance 50.

Electron Tubes in Industry, by L. L. Ludwigsen, General Electric Co. October 23. Attendance 60.

University of British Columbia

Lois River Hydroelectric Project, by R. W. Klinck, student;

Line Starting Equipment for Large Synchronous Motors, by L. Williams, student. October 6. Attendance 17.

Mercury Arc Rectifiers, by P. D. Rossiter, student;

Lightning, by H. M. Van Allen, student. October 20. Attendance 14.

Inspection trip to the Seymour Exchange of the B. C. Telephone Co. October 31. Attendance 12.

An Automatic Smoke Tester, by G. E. Barnes, student;

Thyratron Tubes, by J. N. McRae, student.

Film—"The Wizardy of Wireless." November 3. Attendance 28.

Brooklyn Polytechnic Institute

How the Dial Telephone Works, by E. J. Kane. Bell Telephone Laboratories, Inc. Illustrated. October 20. Attendance 32.

California Institute of Technology

Electrical Advertising and Some of Its Applications to Industry, by Mr. Prosser. October 30. Attendance 29.

University of California

The Life of Edison, by Louis Rockholt, student;

Edison as an Inventor, by Harold Wright, student;

Edison as a Personality, by Forrest Taylor, student.

Two films were shown, as follows: "Edison as a Benefactor" and "Edison as He is Today." October 7. Attendance 61.

Amateur Radio, by Clayton Bane, American Radio Relay League;

Relation of the Radio Amateur to the Radio Industry, by A. H. Babcock, Southern Pacific Co.;

Beam Transmission, by Donald Hall, student. Demonstration of the transmitting and receiving of radio messages at 80 meters. October 21. Attendance 81.

Carnegie Institute of Technology

The A.I.E.E. and the Engineer, by Prof. William R. Work;

The Student and the Institute, by Prof. B. C. Dennison;

History of the C.I.T. Student Branch, by Prof. G. M. Porter, counselor. October 14. Attendance 40.

Case School of Applied Science

An Engineer Visits Europe, by Prof. H. B. Dates, counselor;

Electrical Safety Devices, by J. C. Elder, student.

W. J. Lattin, chairman, gave a summary of the activities at the District meeting held in Pittsburgh March 1931. October 22. Attendance 39.

Catholic University of America

Election of the following officers: Ralph Brady, president; Joseph DeBettencourt, vice-president; James Springmann, treasurer; Robert F. Bourne, secretary. Talk by Prof. T. J. MacKavanagh, counselor, on the purpose of the A.I.E.E. and its benefits to the student. October 21. Attendance 38.

University of Cincinnati

Business meeting. October 12. Attendance 3.

Clarkson College of Technology

Summer experiences were outlined by Prof. A. R. Powers, counselor, and H. Beck and O. C. McNairn, students. October 16. Attendance 24.

Colorado State Agricultural College

Prof. H. G. Jordan and Prof. F. L. Poole, counselor, gave talks on the activities of the Institute and the Student Branch. October 26. Attendance 24.

University of Colorado

The Advanced Course in Electrical Engineering at the General Electric Company, by Professor Palmer. October 7. Attendance 50.

The Madden Dam Project, by H. F. McPhail, U. S. Bureau of Reclamation. Illustrated with slides. October 21. Attendance 60.

Carrier Wave Telephone Circuit, by A. S. Anderson, General Electric Co. November 4. Attendance 90.

University of Denver

Cosmic Rays, by W. Overbeck, student;

Apparatus Used on Cosmic Ray Expedition at Summit Lake, by Paul Barth, student. October 13. Attendance 13.

Film—"Life of Thomas A. Edison." October 26. Attendance 23.

Drexel Institute

Radiation, by E. K. Cliver. October 15. Attendance 26.

Automatic Telephone Switching Equipment, by L. W. Temple, Jr., student. Inspection trip to the Radcliff Exchange of the Bell Telephone Co. of Pa. Dinner preceded the meeting. October 29. Attendance 32.

Duke University

Edison's Life, by Mr. Weaver, student;

Many Inventions of Edison, by Mr. Debrunny, student.

Prof. W. J. Seeley, counselor, outlined Edison's accomplishments and told of his acquaintanc with him during the World War. November 4. Attendance 19.

University of Florida

General discussion of activities for the coming year. October 7. Attendance 28.

G. R. Shafto, Graybar Electric Co., spoke on the trend and development of radio broadcasting. October 19. Attendance 60.

Systems of Street Lighting and Control, by Harvey F. Pierce, student;

Story of the Frequencies, by G. D. Beck, instructor. November 2. Attendance 27.

Georgia School of Technology

Film—"Electric Heat in Industry." October 13. Attendance 75.

University of Idaho

Picnic. September 29. Attendance 30.

University of Illinois

Discussion of activities for future meetings. September 23. Attendance 21.

Social gathering and entertainment. September 30. Attendance 150.

Business meeting. October 7. Attendance 65.

Film—"The Benefactor." October 21. Attendance 45.

Iowa State College

Why Electrical Engineers Should be Affiliated with Their Own Professional Organization, by Prof. F. E. Johnson, counselor. October 7. Attendance 288.

Some Aspects of Power and Communication Systems Affecting Inductive Coordination, by Mr. Carl and two assistants, Northwestern Bell Telephone Co. October 28. Attendance 205.

University of Iowa

Election of the following officers: David Marchant, president; Francis Murray, vice-president; Albert Behnke, secretary-treasurer. September 23. Attendance 45.

Superheterodyne Receivers, by Elwin O'Brien, student. September 30. Attendance 43.

Lightning Disturbances to Power Lines, by I. Piercy, student;

Movietone Films, by L. Travis, student. October 7. Attendance 41.

Current Events, by Ralph Spafford, student;

Parallel Operation of A-C. Generators, by John Weland, student. October 21. Attendance 42.

Kansas State College

Election of the following officers: G. E. Cain, president; E. R. Jensen, vice-president; L. R. Schruben and C. L. Brown, secretaries; W. S. Hemker, treasurer; N. J. Kling, assistant treasurer; D. E. West, corresponding secretary.

The Eye, by Dr. Evans. October 1. Attendance 50. (Evening session.)

The program of the afternoon meeting was the same as that presented in the evening. October 1. Attendance 68.

University of Kentucky

A Review of the Life of Edison, by Z. Pigue, student;

The Life of Faraday, by Thompson Bonzo, student. October 28. Attendance 41.

Lafayette College

Election of following officers: Henry H. Jones, chairman; G. D. Hegeman, Jr., secretary-treasurer.

L. J. Conover, counselor, explained the aims and activities of the A.I.E.E. October 22. Attendance 18.

Lehigh University

The Manufacturing and Testing of High Tension Insulators, by L. B. Huntington, Jr., student;

Automotive Electricity, by G. A. Burn, Mack International Motor Truck Corp. October 15. Attendance 70.

Lewis Institute

Prof. F. A. Rogers, counselor, outlined the privileges and advantages of student enrolment in the Institute. Election of the following officers: L. P. Evans, chairman; H. May, secretary-treasurer. October 22. Attendance 43.

Louisiana State University

Election of the following officers: P. W. Stokeley, chairman; B. F. Marx, vice-chairman; E. R. Wilkinson, secretary. October 17. Attendance 20.

University of Louisville

Relays, by C. B. Eldredge, student. Henry K. Friedman elected secretary. October 9. Attendance 21.

Massachusetts Institute of Technology

Inspection trips to the Milk Street Manual Exchange and Toll Center, and Kenmore Commonwealth Automatic Exchange, both of the American Tel. & Tel. Co. October 20. Attendance 21.

The Relation of Engineering Education to Industrial Careers, by R. I. Rees, assistant vice-president, American Tel. & Tel. Co. Moving pictures and dinner followed this address. October 23. Attendance 250.

Michigan College of Mining and Technology

Three films presented, as follows: "The Life of Thomas Edison," "Trip Through General Electric Works at Schenectady," and "Behind the Lines." October 16. Attendance 56.

J. S. Francis, student, outlined a trip he had taken to several industrial plants in Detroit and emphasized the part played by electricity. October 30. Attendance 26.

Michigan State College

E. W. Moore, chairman, outlined the advantages of student enrolment in the A.I.E.E. October 13. Attendance 19.

Life of Thomas A. Edison, by Carl Stringer, student. Accompanied by a film describing the development of the electric lamp. October 27. Attendance 19.

University of Michigan

The Aims and Purposes of the A.I.E.E., by Prof. S. S. Attwood, counselor. Election of the following officers: Gary Muffly, chairman; R. W. Rockefeller, vice-chairman; John M. Lyon, secretary; Z. C. Lansdale, treasurer. October 15. Attendance 46..

Some Aspects of the Thermal Problem in Electrical Design, by C. J. Fechheimer, Westinghouse Elec. & Mfg. Co. October 31. Attendance 85.

School of Engineering of Milwaukee

Election of the following officers: A. Oklund, president; Gale Young, vice-president; Robert Stephenson, secretary; A. Pflieger, treasurer.

Prof. V. M. Murray stressed the advantages of student enrolment in the Institute.

Trends in Engineering Education, by Dr. J. D. Ball. October 14. Attendance 134.

University of Minnesota

Prof. J. H. Kuhlmann, counselor, gave a talk on the purpose, aims, and activities of the A.I.E.E. and the student Branch. October 22. Attendance 16.

Mississippi A. & M. College

Plan and Purpose of the A.I.E.E., by Dean L. L. Patterson, counselor. Committee appointments announced. October 1. Attendance 30.

Film—"The Single Ridge." October 26. Attendance 26.

University of Missouri

Carrier Current Communication Over High Voltage Lines, by J. E. Shepherd, chairman. October 14. Attendance 31.

Montana State College

Report of the Pacific Coast convention by H. T. Lambdin, chairman. October 1. Attendance 126.

The following papers were presented by students:

Tungsten Bows to the Plating Bath, taken from *Scientific American*, presented by Charles Anderson;

Welding Stresses are Relieved in the Electric Furnace, taken from *Electric Journal*, presented by Herbert Archibald;

Saluda Hydroelectric Development (from *Electric Journal*) presented by Harry Beck;

Sales Talk for General Electric Review, by Everett Blanchard;

Airplane Flight Aided by Electricity (from *Electric Journal*) presented by Eric Blannin;

Producing Noises from Power Transformers, by Arthur Buckley;

Whole World Helps Build Electric Generators (from *Journal of Electric Workers and Operators*) presented by Edgar Dolum;

Development of Gaseous Tube (from Electrical Engineering) presented by Leonard Estey. October 8. Attendance 117.

Graduate Training for Engineers, by Dr. James Tryon, Massachusetts Institute of Technology. October 15. Attendance 120.

The Story of Edison's Life, by Wesley Funk, student;

Edison's Achievements, by Armin Hill, student. October 22. Attendance 109.

The following papers were presented by students:

Speed Street Car for Dresden (from *Railway Journal*) presented by Helmer Fallman;

Stabilization of Industry (from *G. E. Review*) presented by Edward Fisher;

Growlers for Armature Testing (from *Electric Journal*) presented by James Garrison;

Free Wheeling Street Cars (from *Electric Traction*) presented by Vern Hankins;

Dampers Installed on Hot 110-Kv. Line (from *Electrical West*) presented by Curtis Hanson;

Cylinder Pressure Indicator (from *Electric Journal*) presented by Edward Hughes;

Biography of Alman B. Strowger, by Roderick MacDonald. October 29. Attendance 115.

Newark College of Engineering

Electrical Show. October 9. Attendance 158.

Demonstration and lecture by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. October 21. Attendance 200.

Inspection trip to South Amboy power station. October 23. Attendance 32.

Europe — Engineering Observations, by Prof. Paul M. Giesy. November 2. Attendance 31.

University of New Mexico

History and Development of the X-Ray Tube, by A. W. Francis, student;

Theory and Explanation of the X-Ray Tube, by H. Mendenhall, student. October 13. Attendance 20.

General discussion of Branch activities. Martin Zirhut elected vice-chairman. October 15. Attendance 10.

Austin True, chairman, gave a description of the District meeting held at Kansas City. October 28. Attendance 9.

College of the City of New York

General discussion. October 1. Attendance 13.

New York University

The History, Organization, and Activities of the A.I.E.E., by H. H. Henline, assistant national secretary, A.I.E.E. September 29. Attendance 27.

The Life of Michael Faraday, by R. D. Nussbaum, student. October 14. Attendance 16.

North Carolina State College

Purpose and Aims of the A.I.E.E., by G. E. Ritchie, chairman;

Advantages of Membership in the Student Branch, by Professor R. S. Fouraker, counselor. October 6. Attendance 25.

Design and Economics of Distribution Systems, by Mr. Roewe, Carolina Power & Light Co. November 19. Attendance 55.

Setting Poles in Florida with Dynamite, by J. E. Whitehead, student. Film—"The Electric Ship." November 3. Attendance 27.

University of North Carolina

Education by Observation, by Prof. G. T. Schmenning. October 19. Attendance 60.

North Dakota State Agricultural College

Fred Payne elected chairman and Orville Isley, vice-chairman. October 2. Attendance 11.

The State College Engineer, by Rae Taylor, student;

The Student Branch of A.S.M.E., by Leonard Lynstad, student;

The Student Branch of A.I.E.E., by Fred Payne, chairman;

The Importance of Mathematics to Engineering, by Mr. Hartwell, instructor;

Scenes of Constantinople, by Prof. W. E. Smith. Joint meeting with the A.S.M.E. Branch and the Engineers Club. October 8. Attendance 106.

Life of Edison, by Oliver Blecken, student. Film—"The Story of Rail Steel." November 5. Attendance 63.

University of North Dakota

First meeting of the season held to discuss plans for future meetings. September 30. Attendance 15.

Prof. H. F. Rice, counselor, gave a résumé of the summer convention held at Asheville, June 1931. October 14. Attendance 15.

University of Notre Dame

EXPERIENCES IN ENGINEERING WORLD SINCE GRADUATION FROM COLLEGE, by Mr. Moyer, General Electric Co. October 5. Attendance 54.

ELECTRIC LIGHT AND POWER IN THE UNITED STATES, by Mr. Dietrich, Indiana-Michigan Electric Co.;

MERCURY ARC RECTIFIER, by Francis Joseph, student;

LIFE OF MICHAEL FARADAY, by Julian Quinn.

Current news presented by Jack Scanlon. October 19. Attendance 74.

SERVICE INTERRUPTIONS, by W. D. Stamm, Twin Branch Power Plant;

TELEVISION, by William Mitsch, student;

WHY I CHOSE ELECTRICAL ENGINEERING, by Joseph Doherty, student.

Current news presented by Jack Scanlon, student. November 2. Attendance 74.

Ohio State University

Smoker. October 8. Attendance 51.

Ohio University

G. B. Wychoff, chairman, gave a talk on the advantages of student enrolment in the Institute. Charles C. Colombo elected secretary. October 14. Attendance 24.

Oklahoma A. & M. College

MICHAEL FARADAY, by Paul Ratliff, student. October 1. Attendance 19.

JOSEPH HENRY, by Clyde Wyant, student. October 8. Attendance 27.

Prof. A. Naeter, counselor, Paul Ratliff, J. Hutchins, chairman, and V. Smith described the District meeting held in Kansas City in October. October 26. Attendance 26.

Oregon State College

Charles Boyle, Aluminum Company of America, gave a summary of the growth of the aluminum industry during the past 40 years, and pointed out the number of recently found uses for aluminum. The three following films shown: "Blasting a Pre-Cast Dam Into Place," "Construction of the 132-Kv. Line from San Bernardino, Calif., to Hoover Dam," and "Construction of the 110-Kv. Line from Rock Island, Washington, to Skykomish, Washington." October 27. Attendance 77.

University of Pittsburgh

Election of officers as follows: R. A. Hartley, chairman; R. J. Campbell, vice-chairman; J. W. Stirling, Jr., secretary. September 23. Attendance 36.

Professor H. E. Dyche, counselor, outlined the purpose and activities of the A.I.E.E. September 25. Attendance 127.

DEVELOPMENT OF VACUUM TUBES, by R. Kertz, student;

POWER FROM TROPICAL SEAS, by H. S. Long, student. October 1. Attendance 125.

Mr. Goebel, Westinghouse Elec. & Mfg. Co., gave a talk on a Mediterranean cruise and a comparison of European manufacturing methods with those in the United States. October 8. Attendance 125.

FOKKER AIRCRAFT CONSTRUCTION, by W. L. Kaiser, student;

THE ELECTRIC SYSTEM, by L. W. Moline, student. October 15. Attendance 119.

Pratt Institute

Discussion of activities for future meetings. October 15. Attendance 22.

AUTOMATIC CONTROL OF LOAD AND FREQUENCY AS APPLIED TO HYDROELECTRIC STATIONS, by R. Neumann, student. H. P. Miller, of the School of Science and Technology, spoke on the importance of the A.I.E.E. in the engineering profession and the advantages of student enrolment. October 22. Attendance 48.

Purdue University

Prof. C. F. Harding gave a talk on the history and activities of the A.I.E.E. with particular reference to the Student Branches. October 6. Attendance 200.

Rensselaer Polytechnic Institute

Talks on experiences during summer employment were given by seven students. October 13. Attendance 144.

Rice Institute

Film—"Buried Sunshine." October 14. Attendance 17.

Film—"Conowingo." October 28. Attendance 11.

General discussion. November 4. Attendance 27.

Inspection trip. November 6. Attendance 19.

Rose Polytechnic Institute

Election of the following officers: John Montgomery, president; Paul Froeb, secretary-treasurer. October 8. Attendance 18.

Professor C. C. Knipmeyer, counselor, outlined the history, purpose, and benefits of the A.I.E.E. October 21. Attendance 38.

A STUDENT'S ATTITUDE TOWARD HIS WORK, by James Payne, read by Charles MacGillvary, student. October 28. Attendance 39.

Rutgers University

Smoker and organization meeting. Election of officers as follows: Frederick Fisher, president; Floyd Taylor, vice-president; Lucas V. Banta, secretary; Harold Measly, treasurer. September 28. Attendance 27.

University of Santa Clara

APPLICATION OF ALUMINUM TO TRANSMISSION LINE CONSTRUCTION, by Howard Fly, Aluminum Co. of America. Illustrated. Joint meeting with the A.S.M.E. Branch. October 15. Attendance 109.

University of South Carolina

Appointment of executive, meetings and papers, publicity, and membership committees. October 8. Attendance 10.

South Dakota State School of Mines

Harold Jepson elected secretary and Roy Full elected vice-chairman. September 29. Attendance 26.

University of Southern California

Dean P. S. Biegler, chairman, Los Angeles Section, gave a brief survey of the work carried on by the Sections and stressed the importance of students taking an active part in Branch activities. September 16. Attendance 31.

F. G. Philo, Southern California Edison Co., Ltd., gave an illustrated lecture on the development of the present steam plant at Long Beach, Calif. September 23. Attendance 35.

T. M. Blakeslee, Bureau of Water & Power, gave an illustrated talk on the development, design, and uses of the oscillograph, showing the various types of multiple element units. September 30. Attendance 30.

INTERCONNECTIONS BETWEEN SUBSTATIONS AND BETWEEN DIFFERENT POWER COMPANIES, by W. W. Austin, student. October 7. Attendance 25.

INDUSTRIAL APPLICATION OF THE PHOTOELECTRIC CELLS, by Edwin W. Morris, Westinghouse Electric & Mfg. Co. October 14. Attendance 31.

Stanford University

M. R. Jones, Jr., chairman, gave a résumé of the Pacific Coast convention held at Lake Tahoe, in August. October 15. Attendance 30.

Stevens Institute of Technology

Prof. Kenneth S. M. Davidson gave a talk on yacht design. Luncheon served before the meeting. Election of officers as follows: Fernley L. Fuller, chairman; Robert A. Chadburn, secretary. October 30. Attendance 45.

University of Tennessee

THE LARGEST METERED TRANSFORMERS, by E. D. Jones, student. Demonstration of high voltages given by Professor J. G. Tarboux, counselor. October 21. Attendance 40.

Texas A. & M. College

VACUUM TUBES, by C. C. Nash, student. Election of the following officers: R. L. Suggs, chairman; E. Bartel, vice-chairman; G. H. Samuels, secretary-treasurer. October 20. Attendance 45.

Texas Technological College

Atmospheric Electricity, by Charles E. Houston, student. October 15. Attendance 15.

University of Utah

How Does the College Education Pay? by Mr. Huntsman. October 15. Attendance 25.

University of Vermont

Static Electricity, by G. S. Flagg, student. Demonstrated. October 12. Attendance 18.

Virginia Military Institute

The Life of Clerk Maxwell, by J. M. Trossbach, student;

Wind Rotor Generators, by J. B. Taylor, student;

The Economic Side of Public Utilities, by L. B. Jones, student;

The Life of Joseph Henry, by E. L. Kostainsek, student. Prof. S. W. Anderson, counselor, supplemented this paper with some interesting facts concerning, his experiments and his contemporaries. October 24. Attendance 70.

Film—"The Building of the 'U.S.S. Akron,'" November 5. Attendance 94.

Virginia Polytechnic Institute

Insulation of Electrical Apparatus, by S. S. Brown, student. J. V. Burgess, student, gave a report on the Signal Corps of the U.S. Army. October 22. Attendance 38.

Life of Thomas A. Edison, by J. R. Perrine, student;

Research Work in the Electrical Field, by R. P. Hankins, student. October 29. Attendance 43.

Vacuum Tube Millivoltmeter, by W. Richardson, student;

Dial Telephone System, by D. E. Young, student. November 5. Attendance 56.

University of Virginia

Prof. W. S. Rodman, counselor, gave a talk on the history, aims, and purpose of the A.I.E.E. and student enrolment. October 19. Attendance 10.

State College of Washington

Introduction of officers, and report on Pacific Coast Convention. October 1. Attendance 38.

University of Washington

Skagit Project, by Glen H. Smith, City of Seattle, Department of Lighting. Illustrated with slides and motion pictures. October 9. Attendance 20.

The Aspects of Commercial Engineering, by H. M. Gustafson, General Electric Co. October 15. Attendance 24.

Electrical Contracting, by Clifford Johns, student. October 22. Attendance 15.

Telephone Plant, by G. L. Larson, Pacific Telephone & Telegraph Co. October 29. Attendance 24.

Three films shown, as follows: "The Electric Ship," "Beet Sugar Production," and "Conquest of the Cascades." November 5. Attendance 20.

Washington University

Discussion of Branch activities. October 8. Attendance 27.

Business meeting. November 7. Attendance 16.

West Virginia University

The following talks were presented by students:

D-C. Power Transmission, by Kenneth DeMoss;

Bottling Electric Heat, by Morgan Sprigg;

3,600-R.P.M., 60-Cycle, Two-Pole Alternators, by E. L. Engle;

Conowingo Hydroelectric Development, by G. E. Hervey;

Synchronized Films, by V. S. Montieth;

Cylinder Pressure Indicators, by G. L. LeFevre;

Construction of Vacuum Tubes, by R. R. McCue. October 12. Attendance 30.

The following talks were presented by students:

Electrical Resistance Strain Gauge, by S. J. Iaquinta;

Benjamin Garver Lamme, by C. L. Barton, Jr.;

Series Street Lamp Cut-Out, by J. Kayuha;

Testing and Changing Insulators in Service, by P. Skaff;

Lighting System in Detroit City Airport, by D. C. Kennedy. October 19. Attendance 30.

University of Wisconsin

Film—"Glimpses of the Orient." October 6. Attendance 75.

Commercial Engineering, by J. K. Affanasiev, student. October 20. Attendance 55.

University of Wyoming

General discussion of activities for future meetings. October 15. Attendance 12.

The Functioning of the Short Wave Transmitter, by Roy Perkins, student. October 20. Attendance 10.

Life of Edison, by F. W. Wickenkamp, student. Illustrated. G. H. Sechrist, counselor, gave a talk on the activities of the A.I.E.E. November 3. Attendance 23.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ELECTRICAL ENGINEER, graduate, married, 28, with wide experience in industrial plant, electrical construction and maintenance; railway electrification; power plant design, estimating, and supervisory construction. Experience with electric contractor; cost analysis. Desires position with future. C-4428.

RECENT GRADUATE, age 21, single, citizen, good health, Protestant, B.E.E. degree, drafting and clerical experience, organization work. Would like to locate with a firm dealing with illumination or radio. Location, East. C-9756.

EXECUTIVE-MANAGER, public utility property. Technical education, construction, operating, management. Past six years consultant, executive engineer with foreign utility. Previous ten years with nationally known holding company interests. Available immediately. C-4036.

ELECTRICAL ENGINEER, B.S. in E.E. in cooperative college, age 23, experience in radio tube research, physical laboratory tests on synthetic resinoids, and electrical drafting. Desires position in any part of U.S. C-9978.

DISTRICT SALES MANAGER or manufacturer's agent; experienced engineering representative, desires connection with high grade company that has line of industrial or utility equipment. Eastern location preferred. B-4067.

1931 GRADUATE of five year cooperative school in electrical engineering. E.E. degree, age 23, single. Cooperative experience includes machine shop practise, telephone central office trouble shooting, and experience with large municipal fire alarm system. Desires position with manufacturing concern or public utility. Willing to start at bottom. Location, Middlewest preferred, but elsewhere satisfactory. C-9825.

1931 ELECTRICAL ENGINEERING GRADUATE, Midwest university, 23, single. Three months' experience with large public utility. Desires position with any manufacturing firm or public utility. Best of references. Location, immaterial. C-9984.

OVERHEAD DISTRIBUTION ENGINEER, economic cutting of losses, economic transformer spacing, economic wire size, correct voltage, will more than save your company the cost of my salary. Let me show you how I can make your distribution system more economical and efficient. Twenty years' experience. Speaks Spanish, married. United States preferred. C-2453.

FINANCIAL ENGINEER, Cornell (M.E.-E.E.). Twelve years regulator commission; four with utility holding management corporation; eight months intensive course bond buying department leading insurance company; employed almost four years thereafter on financial and fact-finding investigations by outstanding consulting engineering organization. Desires opportunity New York City. Salary open. C-2953.

GRADUATE OF STEVENS INSTITUTE OF TECHNOLOGY, 1931, in mechanical engineering, age 23, and single. Has had experience in communication, electrical installation, test and maintenance for eight years. Conscientious, practical, and willing to do any sort of engineering work. C-9976.

1931 GRADUATE ELECTRICAL ENGINEER, 29, 3 years' cooperative experience with eastern public utility, 5 years' drafting and tool design experience before beginning college course. Single now, married when permanent position obtained. Desires position offering some contact with engineering work. Available on one week's notice. Location, anywhere. C-9834.

GRADUATE ELECTRICAL ENGINEER, 24, B.S. in E.E. Knowledge of design, construction of indicating instruments, also knowledge of electron tube. Two year cooperative course with Weston Electrical Instrument Corporation, (32 departments including shop, office and engineering work). Three years' industrial work before college. Available immediately. Location, United States, Canada. C-9585.

ELECTRICAL ENGINEER, Stanford University 1929; one year Westinghouse Course, six months' experience in manufacturing plant, development and design; nine months' experience in materials testing laboratory, engineering mechanics section, bureau of standards. Desires position in research work in physics or electrical engineering. Available immediately. C-8618.

GRADUATE ELECTRICAL ENGINEER, 22, single. Five years electrician's helper and electrician, experienced on small lighting plants and water systems, six months as machinist, five months Westinghouse Test covering switchboards, circuit breakers, and detailed apparatus. Desires position relating to power generation and distribution. Location, immaterial. C-9981.

ELECTRICAL ENGINEER, 22, single, 1931 technical graduate desires work. Four summers' operating experience in large paper mill. Will go anywhere, speaks Russian. D-23.

ELECTRICAL ENGINEER, married, age 29, graduate B.S. in E.E. 1925, six years' experience in engineering and drafting work with a prominent engineering firm, thoroughly familiar with power station and substation work, both physical and wiring. Desires position with public utility, or manufacturer of electrical equipment. Available immediately. D-22.

GRADUATE ELECTRICAL ENGINEER, married, 34, G. E. Test, and ten years' experience in the utility field, particularly in engineering and maintenance work of underground distribution systems, including a-c. low voltage networks. Desires position with utility in Middlewest or South with responsibility for design or maintenance of distribution system. C-1191.

ELECTRICAL ENGINEER, single, 1928 graduate, G. E. Test. Some power plant and railway substation installation experience, also qualified as radio operator. Considerable experience with mercury arc rectifiers and automatic switchgear. Would prefer position with consulting engineer, or similar firm. D-13.

GRADUATE ELECTRICAL ENGINEER from northern college of cooperative type; B.S. in E.E., 23, single, Protestant. Considerable machine shop and construction experience, automotive practise; two years in cooperative G. E. Test Course, control equipment. Seeking opportunity in engineering design and development. Location and salary secondary to opportunity. Available short notice. D-36.

ELECTRICAL ENGINEER, 32, single, E.E. graduate 1922. Westinghouse Graduate Student Course including electrical design school. Six years' experience induction motor design. One year industrial sales and two years application work on power house auxiliary electrical equipment. Desires position as design, application or sales engineer. Available immediately. Location, immaterial. C-9947.

GRADUATE ELECTRICAL ENGINEER, 24, single, B.S. in E.E., W.P.I. 1931. Four years' experience in construction; one year's experience in transmission work. Desires work in any electrical engineering field. Available at once. Location, optional. D-45.

ELECTRICAL CONSTRUCTION ENGINEER, graduate Case School of Applied Science 1928, age 27, married. Three and one-half years' experience with large electrical contractor in estimating, design, control work and field supervision. Excellent references. Middlewest location preferred. Available immediately. D-46.

SALES ENGINEER, B.S. in E.E. 1926, 27, single, experienced indicating instruments, utility purchasing department, test department, G. E. meter laboratory, radio sales and service, and retail store management. Desires a connection with a future. Location, immaterial. C-9045.

ELECTRICAL DESIGNING ENGINEER, 36. Six years power plant and preliminary studies, for standardization of indoor and outdoor substations. Six months power construction work. Two years drafting, standardization of factory planning and electrical equipment. Two years inspection and testing, of electrical equipment. Desires connection with consulting engineers. New York City preferred. D-14.

GRADUATE ELECTRICAL ENGINEER, 32, married, nine years' experience, research and development of small electrical devices and instruments. Some experience in the construction of photoelectric tubes, light valves and cathode ray oscillographs. Considerable experience in telephone, radio and railway signaling development. Available on two weeks notice. Location in Chicago preferred. D-58.

GRADUATE ELECTRICAL ENGINEER, 32, single, B.S. degree in E.E. Three years Westinghouse Test, seven years supervising power plants, substations and transmission line construction. Eight years engineering inspector, purchasing, expeditor, resident engineer and writing specifications. Excellent reference. Desires connection with holding company, utility, contractor or manufacturer. Available immediately. Location, immaterial. B-9661.

ENGINEER, Electrical, 37, native American, experience:—industrial mills, drives, lighting, generation, control, protection, underground distribution and some transmission, also design, field work, writing of specifications and calculations. Immediate placement anywhere very urgent; and salary can be easily arranged to the satisfaction of interested party. Willing to learn new phase. B-3172.

ELECTRICAL ENGINEER, Pratt graduate 1928, age 24, single. Three years' telephone experience. Knowledge of long and short haul circuit layout, cable including gas pressure protection, underground circuit and pole line construction, economic studies, estimating and technical photography. Available immediately. Location desired, New York City or vicinity. D-59.

ELECTRICAL ENGINEER, 29. University graduate, degree of B.Sc. 1923. Two years' experience with large management and engineering company in Middlewest. Six years' experience with nationally known electrical manufacturing company in sales, design and production departments. Desires position with manufacturing company. Available on short notice. Location, Eastern states preferred. C-9995.

GRADUATE ELECTRICAL ENGINEER, 1929, single, age 23. Fifteen months as student engineer on G. E. Test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or manufacturer. Available at once. Location anywhere in United States. C-8028.

1931 GRADUATE of cooperative college. B.S. in E.E. Age 22, single. Six months' experience with manufacturing company, three months of plant maintenance and fifteen months with public utility. Desires position with any manufacturing, utility or engineering concern. Location, immaterial. Available at once. D-40.

M. I. T. GRADUATE ELECTRICAL ENGINEER, 35, married. Six years' industrial and teaching experience in electrical engineering. Several years private research and development work on own initiative. Good ability, integrity, and personality. Desires university teaching position for life work. Location preferred, Middlewest or South. C-2826.

DISTRIBUTION SUPERINTENDENT, age 46. Twelve years' experience as superintendent of distribution and transmission also metering equipment with public utilities in Central and South America. Spanish spoken fluently. Available now, unemployed. B-9642.

UNIVERSITY OF MAINE GRADUATE, B.S. in E.E., 1929, single, 23, 2½ years drafting, railway signaling. Desires any engineering position. Prefers illuminating engineering or teaching. Location, immaterial. Available immediately. D-65.

ELECTRICAL ENGINEER, 38, married. Seventeen years' experience, design, construction and inspection. Qualified to take complete charge of project from preliminary cost analysis work to finish of construction. Last assignment as superintendent of construction on $20,000,000 electrical and mechanical project. Willing to travel. Salary commensurate with position. Available immediately. B-4456.

SALES EXECUTIVE OR ENGINEER: Graduate electrical engineering and business administration. Three and one-half years sales manager with largest concern in its industry. Two years salesman and branch manager. Five years as engineer in public utility field. Has sales promotional and advertising experience. Would also consider purchasing position. Available immediately. B-7954.

ENGINEERING EXECUTIVE, 33, electrical and mechanical graduate, ten years' experience in management, design, construction, production, accounting, and sales, with steel mill, manufacturer, and utility, desires position as chief engineer, works manager, or other executive capacity where a calm, judicial disposition coupled with initiative and aggressiveness will show up in results. C-1297.

ELECTRICAL ENGINEER, 26, single, E.E., two years' public utility experience in construction, distribution, tests of equipment and domestic appliances, and investigations of abnormal conditions. Three years' clerical experience in cost of production. Can handle responsibility. Desires position with public utility, contractor, or manufacturer. References. Location, immaterial. Available immediately. D-47.

ELECTRICAL ENGINEER, E.E. degree, 36, single. Fourteen years' experience public utilities covering valuation work, rate investigations, engineering power plants, substations, transmission lines, including estimates, specifications, design. Experience covers short-circuit studies, stability analysis, investigations of systems for load conditions. Desires position, holding company, operating company, or consulting engineer. Available immediate. C-9570.

ELECTRICAL ENGINEER, 45, married, graduate of Virginia Polytechnic Institute, 1909, B.S. in E.E. Twenty-three years' experience with the Bell System and the International Telephone and Telegraph Corporation in telephone central office equipment design and planning for toll, manual and automatic dial operations. D-48.

ELECTRICAL MECHANICAL ENGINEER, six years' varied design, construction and operating experience on electrified railroads; familiar with valuation work and the design of transmission lines, catenary systems, substations and motive power. American, college graduate, membership in A.S.M.E., A.I.E.E., A.E.R.E.A., A.R.A. Wishes position anywhere with consulting firm, power company, railroad or manufacturer. C-8463.

ELECTRICAL ENGINEER, university graduate, 1910, experience principally in power and light electrical engineering. Desires position offering similar or electric railway experience. Eastern location preferred. B-1923.

TRACTION ENGINEER, 28, single, five years' experience electric traction shops as inspector, since then and at present in charge of service of the Southeast on registers. Two years at Georgia Tech., later graduated in electrical engineering from I. C. S. Was radio operator. Desires position as assistant engineer for electric traction. D-80.

ELECTRICAL-MECHANICAL ENGINEER, graduate of M.I.T. 1919. Competent, resourceful, sincere. Eleven years' experience in telephone circuits, radio retailing and manufacturing, sound equipment design. Desires mechanical development design in similar fields or research work in the application of vacuum tubes to voice or allied channels. C-310.

ELECTRICAL ENGINEER, 30, married, Wisconsin graduate. Two years construction; Westinghouse Course, two years traction engineering; one year appraisals; four years industrial engineering sales development work. Broad knowledge various industries. Special preparation in economics. Desires employment in surveys for financial or commercial firm; investigations; industrial sales; power sales. Location, East, Middlewest. C-3082.

ELECTRICAL ENGINEER, 27, single, experienced in estimating, detailing and layout of substations, transmission, and distribution lines. Also relay testing. Desires position with utility or engineering concern. Location, immaterial. D-89.

GRADUATE COMMUNICATIONS ENGINEER, Purdue, 1930. Age 24, married, experience with the communication problems of railway service. Familiar with Western Union and Bell System service. Also considerable practical work with control equipment, instrument repair and maintenance, and with radio. Location, immaterial. Available on short notice. D-88.

GRADUATE ELECTRICAL ENGINEER, 35, married, 12½ years' experience in low tension equipment and signaling devices. Thoroughly familiar with devices involving time element and controlling apparatus for special applications. Has had designing and manufacturing experience. Location, immaterial. Will accept foreign appointment. Available at once. C-3820.

GRADUATE ELECTRICAL ENGINEER, 33, married, 3 years radio telegraph, 9 years supervision standardization involving: Distribution system materials, construction, generating stations, substations, special equipment, material design, insulation coordination, simplified practises in purchasing, etc. Desires position, sales, distribution, cable; industrial simplified practise; general engineer where practical inventive, developmental ability is required. Prefers Midwest, Southeast. D-44.

DESIGN ENGINEER, native American, age 33, married, technical education, industrial and mining experience, steam and Diesel power plants, auxiliaries, automatic substations, ability to handle men, can write specifications, knowledge of concrete and steel design, air compressor and ventilation installations. Location, Central U.S.A. preferred. C-9849.

SUPERINTENDENT of distribution, 44, married. Graduate Lowell Institute School, Auspices Massachusetts Institute Technology, electrical, industrial management courses. Twenty years' electric utility operating experience; engineering, construction, operation, maintenance of distribution, transmission lines, substations, transportation, first aid, educational works. Has sufficient public utility operating experience to qualify for position of superintendent. C-8411.

1931 GRADUATE IN ELECTRICAL ENGINEERING, B.S., Worcester Polytechnic Institute, single, 22. Desires connection with manufacturing or public utility concern. Location and salary secondary, experience, primary consideration. C-9627.

GRADUATE IN ELECTRICAL ENGINEERING, 1931, age 26, single, has B.S. in E.E. One year of electrical testing with large utility company. One year of electrical drafting of power and control switchboads. Three years' work in practical electricity. Interested in construction and supervision of small plants. Available at once. Location, anywhere. C-9457.

ELECTRICAL ENGINEER, married, university graduate, E.E., M.E. Twenty-two years' experience, designing, construction power plants, substations, transmission, distribution systems, industrial plants. Three years' executive experience charge engineering department large utility syndicate. Three years charge purchasing engineering equipment, foreign interests. Reads, speaks fluently English, German, Russian, Turkish languages. Available immediately. D-84.

ELECTRICAL ENGINEER, 33, married, B.S. E.E. 1921. Ten years automotive maintenance. G. E. Test. Three years designing a-c., d-c. motors, generators, arc welding equipment, control. Three years developing, designing d-c. motors, generators, control for automotive drive. Three years automotive development, maintenance bus, cab company. Interested, electrical automotive, design, maintenance. D-95.

ELECTRICAL ENGINEER, 25, single, B.S. in E.E., 1931, desires work. Interested in manufacture of electrical machinery or radio. D-97.

GRADUATE ELECTRICAL ENGINEER, young, single. Electrical and accounting education. Journeyman electrician experienced in industrial and commercial construction. Also two years with public utility engineering division. Desires position with industrial or contracting concern or with sales organization. Location, foreign or Western U.S., isolated plants satisfactory. D-96.

ELECTRICAL ENGINEER, age 45, technical school graduate, desires position with railway, industrial plant or consulting engineer. Twenty-four years' experience with large street railway and electrical contractor on designing, estimating, construction, and operation, electrical and mechanical. Has had considerable executive responsibility. Conversant with power reports and new projects. Prefer East. C-7202.

ELECTRICAL-MECHANICAL ENGINEER with metallurgical knowledge. College graduate with post-graduate study. Age 30, married. Westinghouse design training. Six years' experience design electrical circuits and mechanical details of control apparatus, specialized in elevator equipment. Interested in alloy welding research. Location, immaterial. Available on short notice. C-9638.

ELECTRICAL ENGINEER, 1931. Slight experience in vacuum tubes, and their application, also with resistor units. Sales experience in radio, telephone and sound systems. Desires position in research, radio, television or sound. Available now. C-5636.

SALES EXECUTIVE ENGINEER, electrical and mechanical training, seven years' sales engineering and executive experience in application of precision equipment to electrical equipment. Would like opportunity to develop sales of mechanical product allied with electrical industry or of electrical nature sold to central stations and industrials. Willing to tackle difficult job. C-5431.

COMMUNICATION ENGINEER, 31, single. Experienced telephone, radio installations; design, development of testing equipment for telephone, radio, sound picture circuits; design, use of semi-full automatic testing circuits to eliminate human element in testing; industrial applications of photoelectric cells, thermionic tubes. Best references as to professional ability, personal integrity. Location immaterial. Available immediately. C-9376.

Membership

Recommended for Transfer

The board of examiners, at its meeting of October 20, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Carhart, Frank M., partner, Jackson & Moreland, Boston, Mass.

To Grade of Member

Giese, Raymond C., division plant engr., American Tel. & Tel. Co., Denver, Colo.
Higson, Charles R., supt. of distribution, Utah Pr. & Lt. Co., Salt Lake City, Utah
Hughes, M. C., acting head of elec. engg. dept., Texas A. & M. College, College Station, Texas
Putman, Henry V., manager, transformer engg. dept., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Rode, Norman F., professor of elec. engg., Texas A. & M. College, College Station, Texas
Smith, Robert P., sales engr., Westinghouse Elec. & Mfg. Co., Jacksonville, Fla.
Tabb, Warner T., consulting-technical writing, Gloucester, Va.
Tangie, Alexander A., chief installation inspector, electricity dept., Town Hall, Sydney, N. S. W., Australia

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before December 31, 1931.

Ackerman, C. D., Peerless Bread Machine Co., Sidney, Ohio
Addy, J. G., Jr. (Member) Marc Eidlitz & Son, New York, N. Y.
Andujar, M. K., Philadelphia Business Progress Association, Philadelphia, Pa.
Ashmore, O. B., Dallas Power & Light Co., Dallas, Tex.
Actzine, A. D., Canadian & General Finance Co., Ltd., Toronto, Ont., Can.
Ayers, E. H., General Electric Co., Schenectady, N. Y.
Bassiliades, D., University of Wisconsin, Madison, Wis.
Baum, W. U., Pennsylvania Power & Light Co., Northampton, Pa.
Baumann, G. H., Pennsylvania Railroad, New York, N. Y.
Baumgartner, C. W., Kansas City Pr. & Lt. Co., Kansas City, Mo.
Becker, D. E., Marquette University, Milwaukee, Wis.
Bixby, W. H., University of Michigan, Ann Arbor, Mich.
Book, C. F., Hydro-electric Power Comm. of Ontario, Niagara Falls, Ont., Can.
Boren, J. S., 412 Mercedes Ave., Pasadena, Calif.
Bosman, I. A., Board of Public Works, Holland, Mich.
Boulavin, L. B., Brooklyn Edison Co., Brooklyn, N. Y.
Bourne, R. D., Dallas Power & Light Co., Dallas, Tex.
Bretschneider, M. E., Kansas City Power & Light Co., Kansas City, Mo.
Brotzman, E. S., American Tel. & Tel. Co., Charleston, W. Va.
Brown, J. G., 127 Montgomery St., San Francisco, Calif.
Brown, W. B., 68 Forest Ave., Hawthorne, N. J.
Bruncke, H. P., Northern States Power Co., St. Paul, Minn.
Brusa, A. L., R. F. D. No. 1, Waterford, Conn.
Byrne, J. F., Ohio State University, Columbus, Ohio
Capon, A. E., 1224 Oberlin Drive, Glendale, Calif.
Chia, Y., 151 Scotland Road, South Orange, N. J.
Conroy, E. G., American Tel. & Tel. Co., South Bend, Ind.
Craig, W. D., Jr., Duquesne Light Co., Pittsburgh, Pa.
Crain, R. A., Southwestern Gas & Electric Co., Shreveport, La.
Cramond, R. B., New York Edison Co., New York, N. Y.
Crosby, L. W., 12 Elmwood Rd., Swampscott, Mass.
Crowell, D. C., General Cable Corp., Emeryville, Calif.
Crowson, F. B., Jr., American Tel. & Tel. Co., Shreveport, La.
Cummings, H. F., General Electric Co., Fort Wayne, Ind.
Danziger, S., 709 East 9th St., New York, N. Y.
Darley, W. G., General Electric Co., Cleveland, Ohio
Dawson, J. A., The Ohio Bell Telephone Co., Columbus, Ohio
Dial, G. T., New York Edison Co., New York, N. Y.
Di Toro, M. J., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Dudley, B., Institute of Radio Engineers, New York, N. Y.
Eastman, F. H., Jr., General Electric Co., Schenectady, N. Y.
Ellett, R. T., The Virginian Railway, Christiansburg, Va.
Engvall, L. R., Vega, Wash.
Erdos, E. J., Third Ave. Elec. & Supply Co., New York, N. Y.
Fager, C. R., General Electric Co., Los Angeles, Calif.
Farren, G. H., General Electric Co., Los Angeles, Calif.
Ferns, J. H., Stanford University, Stanford University, Calif.
Folsom, R. A., The Ohio Bell Tel. Co., Columbus, Ohio
Fort, R. I., 326 St. Clair St., Frankfort, Ky.
Franklin, W. S., J. E. Fast & Co., Chicago, Ill.
Frick, C. H., Valparaiso University, Valparaiso, Ind.
Ganzer, E. A. W., 12924 Division St., Blue Island, Ill.
Gardner, E. R., General Electric Co., Schenectady, N. Y.
Gardner, R. H., Grafton, Ohio
Garrison, H. D., Bell Tel. Laboratories, New York, N. Y.
Geisz, W. R., Mount Carroll, Ill.
Gerber, P. D., R. C. A. Victor Co., Inc., Camden, N. J.
Glimp, M. A., Jr., Westinghouse Elec. & Mfg. Co., St. Louis, Mo.
Goetz, L. W., Wisconsin Telephone Co., Milwaukee, Wis.
Gray, E. T., Lincoln Power Co., Howe, Okla.
Green, I. L., Federal Telegraph Co., Palo Alto, Calif.

Grimm, C. J., Union Electric Lt. & Pr. Co., St. Louis, Mo.
Groch, F. R., Pacific Gas & Elec. Co., San Francisco, Calif.
Gurnham, R. G., Brown University, Providence, R. I.
Gussow, P. M., 914 First Court, Brooklyn, N. Y.
Gustafson, J. M., Commonwealth Edison Co., Chicago, Ill.
Hagmann, V., General Electric Co., Erie, Pa.
Hamilton, B. W., (Member) Montana Power Co., Great Falls, Montana
Hansford, E. M., General Electric Co., Schenectady, N. Y.
Hartwell, E. M., Electric Light Power & Railroad Co., Paul Smith's, New York
Hauser, H. T., City of San Francisco, Moccasin Power House, Moccasin, Calif.
Henschk , W. O., Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Hill, G. L., Pacific Gas & Electric Co., Emerville, Calif.
Hollis, R. W., Jr., State of California, San Francisco, Calif.
Houston, C. E., Texas Technological College, Lubbock, Tex.
How, J. H., Stanford University, Stanford University, Calif.
Hubbard, W. N., The Bristol Co., Waterbury, Conn.
Hubbell, M. F., Emerson Electric Co., St. Louis, Mo.
Hulse, H. A., Jr., University of Colorado, Boulder, Colo.
Hutchinson, W. J. B., Bell Tel. Co. of Canada, Montreal, Que., Can.
Jablonski, J., Board of Education, Boys High School, Brooklyn, New York
Jagou, C. C., Westinghouse Electric International Co., Mexico, D. F., Mex.
James C. A., General Railway Signal Co., Rochester, N. Y.
Jochem, T. B., Marquette School of Engineering, Milwaukee, Wis.
Johnson, A. A., New York Edison Co., New York, N. Y.
Johnson, J. O., 26 Robinson Court, Burlington, Vt.
Johnson, R. L., New York Edison Co., New York, N. Y.
Jones, D. R., Philadelphia Electric Co., Philadelphia, Pa.
Karr, J. H., Purdue University, Lafayette, Ind.
Keeler, C. E., Yale Graduate School, New Haven, Conn.
Kelly, J. J., Fore River Shipbuilding Corp., Quincy, Mass.
Keltz, E. L., Wichita Cotton Oil Co., Electra Tex.
Kirwen, M. S., Allied Engineers, Inc., Muskegon, Mich.
Kober, W., 652 Southern Blvd., New York, N. Y.
Koehler, J. W., Can. General Electric Co., Ltd., Toronto, Ont., Can.
Krasnow, S., Jr., Bureau of Standards, Washington, D. C.
Kroitzsh, H., Suburban Gas & Electric Co., Revere, Mass.
Kuney, H. M., Goulds Pumps Inc., Seneca Falls, N. Y.
Lambert, W. H., Pennsylvania Electric Co., Johnstown, Pa.
LaPlante, R., Shawinigan Water & Power Co., Montreal, Que., Can.
Larose, V. A., Roland T. Oakes, Holyoke, Mass.
Lash, C. C., College of the Pacific, Stockton, Calif.
Lazo, N., New York Telephone Co., New York, N. Y.
Leeds, W. M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Leiss, E. A., Radio Corp. of America, Harrison, N. J.
Lepone, R. G., R. C. A. Victor Co., Camden, N. J.
Levine, S. J., General Electric Co., Schenectady, N. J.
Lingary, J. W. (Member) Lynn Gas & Elec. Co., Lynn, Mass.
Little, G. R., University of Southern California, Los Angeles, Calif.
Locke, W. W., Jr., Worcester Polytechnic Institute, Worcester, Mass.
Malar, P. P., 188 Dundaff St., Carbondale, Pa.
Markow, A., New York Edison Co., New York, N. Y.
Marks, L. W., Johns Hopkins University, Baltimore, Md.
Martinoff, V. M., Hydro-Electric Power Comm. of Ont., Toronto, Ont., Can.
Matheson, D. R., Armour Institute of Technology, Chicago, Ill.
Matthews, G. D., Peoples Gas Light & Coke Co., Chicago, Ill.
Mayott, W. E., Brooklyn Edison Co., Brooklyn, N. Y.
McBride, A. W., General Development Co., Dallas, Tex.
McCauley, A. D., American Tel. & Tel. Co., Denver, Colo
McConaghy, L. B., Ohio Edison Co., Akron, Ohio
McCurdy, J. D., Cutler-Hammer, Inc., Milwaukee, Wis.
McLennan, A. J., Mass. Institute of Technology, Cambridge, Mass.
Mendez, D. P., General Electric Co., Schenectady, N. Y.
Merriman, J. H., Northern States Power Co., Minneapolis, Minn.
Mesh, T. J., United Electric Light Co., Springfield, Mass.
Meyer, J. C., Allen Bradley Co., Milwaukee, Wis
Miller, V. W., Texas Electric Service Co., Fort Worth, Tex.
Molinaro, A. D., Philadelphia Electric Co., Philadelphia, Pa.
Moorhaus, A. C., Union Gas & Elec. Co., Cincinnati, Ohio
Morrison, R. L., Pamar's Radio Shop, Newberry, Pa.
Murtagh, T. P., New York Edison Co., New York, N. Y.
Nelson, R. A., John Brown Schools, Siloam Springs, Ark.
Nomann, A. B., R. F. D. 1, Whittier, Calif.
Oberwise, M. L., Allen-Bradley Co., Milwaukee, Wis.
O'Sullivan, R. G., Brooklyn Edison Co., Brooklyn, N. Y.
Park, O. P., 1114 Ashland Ave., River Forest, Ill.
Patel, R. M., Cornell University, Ithaca, N. Y.
Plomasen, O. G., Rochester Athenaeum & Mechanics Institute, Rochester, N. Y.
Plumb, C. E., General Electric S. A., Mexico, D. F., Mex.
Plymire, R. F., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Potts, J. C., The Electric Storage Battery Co., Washington, D. C.
Preston, W. W., B. C. Electric Railway Co., Vancouver, B. C., Can.
Queen, W. H., United Air Lines, Chicago, Ill.
Quistorff, W., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Reed, H. E., Maine Seaboard Paper Co., Bucksport, Me.
Reich, H. J., University of Illinois, Urbana, Ill.
Rieger, M., Jr., Western Electric Co., Kearny, N. J.
Roe, J. H., University of Minnesota, St. Paul, Minn.
Roland, S. W., University of Missouri, Columbia, Mo.
Rosenfeld, M., Union Switch & Signal Co., Swissvale, Pa.
Rowe, H. E., General Electric Co., Schenectady, N. Y.
Rucker, S. J., 465 Central Park West, New York, N. Y.
Sackman, G. W., Western Electric Co., Chicago, Ill.
Seielstad, H. D., Cadillac Motor Car Co., Detroit, Mich.
Shnaerof, H. L., Teleregister Corp., New York, N. Y.
Siebenmorgen, R. J., Electro Service Inc., Union City, N. J.
Silk, H., 123 Water St., Paterson, N. J.
Sinclair, A., Detroit Edison Co., Detroit, Mich.
Smith, F. D. (Member) United Lt. & Pr. Eng. & Const. Co., Davenport, Ia.

December 1931

Order Form for Pamphlet Copies of A.I.E.E. Papers

Papers presented prior to September 1931 and upon which articles in this issue are based

Number	Author	Title
☐ 30-144	F. E. Terman, D. E. Chambers and E. H. Fisher	Harmonic Generation by Means of Grid Circuit Distortion
☐ 31-37	C. G. Suits	Studies in Non-Linear Circuits
☐ 31-46	G. Kron	Induction Motor Slot Combinations
☐ 31-53	S. S. Attwood, W. C. Dow and W. Krausnick	Reignition of Metallic A-C. Arcs in Air
☐ 31-54	J. Slepian and A. P. Strom	Arcs in Low-Voltage A-C. Networks
☐ 31-56	H. S. Davis and W. H. Ross	The Philadelphia A-C. Network System
☐ 31-60	Edith Clarke	Simultaneous Faults on Three-Phase Systems
☐ 31-69	C. F. Estwick	The Three-Circuit Transformer
☐ 31-71	P. H. Trickey	Cusps in the Speed-Torque Curves of Induction Motors
☐ 31-72	H. B. Dwight	Proximity Effect in Cable Sheaths
☐ 31-75	E. A. Church	Temperatures in Electric Power Cables Under Variable Loading
☐ 31-90	T. E. Browne, Jr	Extinction of Short A-C. Arcs
☐ 31-96	L. V. Bewley	Transient Oscillations in Distributed Circuits
☐ 31-105	L. A. Kilgore	Calculation of Synchronous Machine Constants
☐ 31-114	S. H. Wright	Determination of Synchronous Machine Constants by Test
☐ 31-115	E. Weber	Field Transients in Magnetic Systems

*Members, Enrolled Students, and subscribers are entitled to one pamphlet copy of any paper in this list if requested within one year from above date. Thereafter a charge of 25 cents per copy will obtain.

Address **Order Department A.I.E.E.**
33 West 39th Street, New York, N. Y.

Name..
Street Address.....................................
City.............................. State...............

☐ **Annual Index for ELECTRICAL ENGINEERING V. 50, 1931**

Published separately in pamphlet form, one copy available upon request to each member or subscriber. The edition of this index will be governed by the number of requests received prior to January 15, 1932; printing and mailing will be deferred until after that date.

Snyder, L., Snyder Electric Shop, Glens Falls, N. Y.
Spittal, W. R., Ferranti, Inc., New York, N. Y.
Stadtfeld, N., Jr., United Elec. Lt. & Pr. Co., New York, N. Y.
Steele, E. S., Royal, Iowa
Steinbrenner, G., 1311 Pierce Ave., Niagara Falls, N. Y.
Stevens, C., Laddonia, Mo.
Stewart, W. E., Nebraska Wesleyan University, Lincoln, Nebr.
Stoddard, H. R., Simplex Wire & Cable Co., Cambridge, Mass.
Stortz, F. A., Jr., General Electric Co., Schenectady, N. Y.
Strawn, T. F., The Home Insurance Co., Quakertown, Pa.
Strommer, E. N., University of Pittsburgh, Pittsburgh, Pa.
Strupp, P. J., R. R. 2, Hartford, Wis.
Suhr, F. W., University of Minnesota, Minneapolis, Minn.
Sylvester, R. A., 417 South Center St., Pottsville, Pa.
Temple, H. P., Wagner Quarries Co., Sandusky, Ohio
Thurm, R. W., Engineering School of Milwaukee, Milwaukee, Wis.
Titter, B. K., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Troja, J. B., General Electric Co., Schenectady, N. Y.
Umlauf, A., General Electric Co., Schenectady, N. Y.
Vance, P. E., U. S. Engineer Office, Memphis, Tenn.
White, T. F. (Member) Texas Construction Co., Dallas, Tex.
Whitney, F. J., Jr., Lehigh University, Bethlehem, Pa.
Wilder, A. F., 36 Joy St., Boston, Mass.
Witt, F. L., Brooklyn Edison Co., Brooklyn, N. Y.
Wyman, K. S., U. S. Patent Office, Washington, D. C.
Young, F. E., Jr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Younts, G. L., General Electric Co., Schenectady, N. Y.
Zilm, W. E., Drexel Institute, Philadelphia, Pa.
Zoercher, J. M., Indianapolis Pr. & Lt. Co., Indianapolis, Ind.
188 Domestic

Foreign

Chen, Y. C., Eastern Sales & Engineering Co., Tientsin, China
Kouyoumdjian, T., Lynch St., Bagdad, Irak
Mitchell, J. W. E., Public Works Dept., Shannon, N. Z.
NagaRajan, T. V., The Andrha Valley Power Supply Co., Ltd., Bhivpuri, Bombay Presidency, India
Tandon, P. L., Cantt. Board, Ambala, Punjab, India
Wadhera, C. L., c/o Lloyds Bank Ltd., New Delhi, India
6 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Balaguer, Manuel M., c/o International Tel. & Tel. Co., 67 Broad St., New York, N. Y.
Byrns, William J., 50 Olive Walk, Breezy Pt., Rockaway Point, N. Y.
Cater, C., Sandal, Church Road, Pinner, Eng.
Chilofsky, Joseph, 958 N. 7th St., Philadelphia, Pa.
Cordier, N. A., 126 Chatterton Pkwy., White Plains, N. Y.
Farnlof, Charles G. T., 1318 Laketon Road, Wilkinsburg, Pa.
Garrison, F. G., Internat'l Tel. & Tel. Corp., Buenos Aires, Arg., So. Amer.
Gaylord, R. H., 1814 Virginia Road, Los Angeles, Calif.
Goldsman, Jacob L., 64 Priory Rd., Hampstead, London, Eng.
Kamm, J. Lloyd, 1802 N. Lamar St., Dallas, Texas.
McCulloch, G. B., McVie Caterers, Ltd., Sydney, N. S. W., Australia
Melson, Sydney W., Yeatton Woolrich Road, Abbey Wood, London, S. E. 2, England.
Mountain, C. E., Burma Elec. Supply Co., Mandalay, Burma, India.
Parr, J. C., 245-71st Street, Brooklyn, N. Y.
Pernick, A. S., Westinghouse High Voltage Lab., Trafford, Pa.
Pierson, Walter D., 4710 Locust St., Philadelphia, Pa.
Pistorius, L. H., 193 Jeppe St., Johannesburg, South Africa.
Schrock, John E., 3720 Main St., Lawrence Park, Erie, Pa.
Stempfle, Frederick, 8126 E. Vernor Highway, Detroit, Mich.
Tate, William, Apartado No. 41, Publa, Mexico.
Thakkur, K. B., Box 654, Whiting, Ind.
Voronovsky, T. G., 1162 Waverly Place, Schenectady, N. Y.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during October are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

WHO'S WHO IN ENGINEERING. Edited by W. S. Downs and M. M. Lewis. 3rd ed., 1931. N. Y., Lewis Historical Publ. Co. 1536 pp., 10 x 6 in., cloth, $10.00.——The third edition of this useful work of reference is restricted, in accordance with the recommendations of the advisory committee appointed by the American Engineering Council, to living American engineers who have been practising or teaching engineering for at least ten years. About ten thousand names are included, with authentic brief information regarding professional experience, publications, education, addresses, etc. A geographic index is given.

GEOLOGIC INDEX OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY. By G. H. Albertson. Denver, Col., Geological Publ. Co., 1931. 420 pp., 10 x 7 in., leather, $10.00.——Geologists and engineers who have occasion to consult the publications of the United States Geological Survey owe a debt of gratitude to the compiler of this index. It covers all the publications of the Survey and is classified by the latitude and longitude of each locality, the unit being a thirty-minute quadrangle. Key maps make it easy to locate the desired entry, where all the references to the locality will be found.

STARS IN THEIR COURSES. By J. Jeans. N. Y., Macmillan Co.; Cambridge, England, University Press, 1931. 173 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth, $2.50.——This work, based upon a series of radio talks, is a delightful introduction to modern astronomy written in an informal conversational style by a great astronomer. Starting with a general account of the heavens, the sun's family, the stars, the milky way and the universe as a whole are discussed. Two star maps and a description make possible the identification of the constellations. The book is ideal for the general reader.

1931 SUPPLEMENT TO BOOK OF A.S.T.M. STANDARDS. Philadelphia, American Society for Testing Materials, 1931. 144 pp., 9 x 6 in., paper, $1.50.——This supplement brings up to date the 1930 Book of Standards published by the Association. It contains thirty-two standards, seventeen of which are new and fifteen replacements of former ones. Among them are specifications for alloy-steel, bolting material for high-temperature service; welded wrought-iron pipe; high-test gray-iron castings; aluminum-alloy sheets and castings; hydrated lime; structural clay tile; white and red lead; and bronze powders. Methods are given for testing concrete, brick, pigments, slate, insulating oils, and other materials.

ALTERNATING-CURRENT CIRCUITS. By J. M. Bryant and J. A. Correll. 2nd ed. N. Y., McGraw-Hill Book Co., 1931. 492 pp., diagrs., charts, tables, 9 x 6 in., cloth, $4.50.——An introductory course in the study of a-c. circuits and transmission lines, based upon that given at the University of Texas. The theory of alternating currents first is discussed, and the equations that apply to the various types of circuits developed from the fundamental physical and mathematical principles. In the latter part of the book these principles are applied to polyphase circuits and transmission lines. This edition has been revised, and a new chapter on the consideration of unbalanced polyphase circuits by means of symmetrical phase components has been added.

ELECTROCHEMISTRY. By C. J. Brockman. N. Y., D. Van Nostrand Co., 1931. 348 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——This book aims to point out the more important applications of the electrical current in chemical manufactures, in a manner that will interest chemists, manufacturers, and plant managers. The general principles are followed by descriptions of the electrometallurgy of the industrial metals, the production of gases and of electrothermal processes. References to sources are numerous.

FRACTIONAL HORSE POWER MOTORS. By A. H. Avery. Lond. & N. Y., Isaac Pitman & Sons, 1931. 152 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth, 7s 6d; $2.25.——The essential features of motors with power outputs of less than ½ hp. are presented concisely. Design, constructional features, commutaton and insulation are discussed. Testing and repairing are considered also.

INDUSTRIAL ELECTROCHEMISTRY. By C. L. Mantell. N. Y., McGraw-Hill Book Co., 1931. 528 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $5.00.——Intended both as a textbook in chemical engineering courses and as a work of reference, this book is written from the engineering point of view and stresses the practical aspects of electrochemical processes. Introductory sections on theoretical and technical electrochemistry are followed by sections on electrolytics, electrothermics, and the electrochemistry of gases, in which the industrial uses for winning, plating, refining and melting metals, for manufacturing gases and chemicals, etc., are described. A final section, engineering, discusses materials and power generation.

MESSENTLADUNGSSTRECKEN (Ionenstrecken). By S. Franck. Berlin, J. Springer, 1931. 192 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, 18.50 RM. unbound; 19.50 RM. bound.——This monograph aims to describe the uses of self-maintaining electrical discharges through gases for purposes of measurement and to give exact particulars of the various methods. The widely scattered literature is reviewed quite thoroughly, and full references are given to the original papers. The theory of discharges through gases is presented very briefly, as an introduction to the methods of measurement.

MONOGRAPHS ON PHYSICAL SUBJECTS. N. Y., E. P. Dutton & Co., 1931. Diagrs., charts, tables, 7 x 4 in., cloth, $1.10 each.——(1) Commutator Motor. By F. J. Teago. 80 p. (2) Photochemistry. By D. W. G. Style. 96 p. (3) Thermodyanmics. By A. W. Porter. 96 p. These concise little volumes by men actively engaged in research work on the subjects about which they write, are intended to supply readers of average scientific attainments with compact statements of the modern position in each subject. They are admirably adapted to the needs of those not in contact with active scientific work or engaged on work in related sciences who wish to become quickly conversant with the accepted principles in various fields.

Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Armatures

MEASUREMENTS. An Electrical Method for Determining the Moment of Inertia of a Direct-Current Armature, J. C. Prescott. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1179-1183, 3 figs. Method of determination described requires for its application d-c. quantity meter in addition to voltmeter and ammeter used in method described by G. Kapp; theory and application of this "quantity meter" method are investigated and experimental results are cited to show degree of accuracy that can be obtained.

Cables

LEAD SHEATHING. Lead Covered Cable. *Wire*, vol. 6, no. 10, Oct. 1931, pp. 402-404, 5 figs. Types and uses of lead cable as compiled by Lead Assn.; cable using lead covering; cable sheath metal; telephone cables; power cable; voltages.

SUBMARINE—PROTECTION. Protective Cable Anchoring. *Elec. Rev.*, vol. 109, no. 2802, Aug. 7, 1931, pp. 209-210, 6 figs. Instance of submarine power cables withstanding ship's dragging anchor.

TELEPHONE. British Columbia 1931 Telephone Cable, M. C. Timms. *Telephony*, vol. 101, no. 13, Sept. 26, 1931, pp. 30 and 32, 4 figs. Gutta-percha insulated submarine telephone cable laid by British Columbia Telephone Co., between Mainland and Vancouver Island, Can.; construction identical to that of ocean cables; manufacturing methods.

Condensers

MEASUREMENT. Measurement of Small Capacities, V. V. Sathe and T. S. Rangachari. *Wireless Engr.*, vol. 8, no. 97, Oct. 1931, pp. 543-547, 7 figs. Compact and self-contained d-c. tubes operated arrangement working on principle of substitution is described for measuring capacities from .002 microfarad down to minute capacities such as inter-electrode capacities of tubes.

Conductivity

On the Resistance of Lead to High-Frequency Currents at Superconducting Temperatures, J. C. McLennan, A. C. Burton, A. Pitt, and J. O. Wilhelm. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 78, Sept. 1931, pp. 707-719, 5 figs. Attempts to find changes in behavior of lead paralleling that of superconductivity for very high frequencies of light waves; in designing experiment highest frequency amenable to accurate measurements, *i. e.*, 10,000 kc. per sec. was chosen; with currents of this frequency phenomenon of superconductivity might occur at lower temperature than 7.2 deg. K., might be only partial, or might not appear at all.

Conduits

CONSTRUCTION. Conduit and Manhole Construction. *Elec. News*, vol. 40, no. 18, Sept. 15, 1931, pp. 41-44, 6 figs. Bell forms of conduit simplify duct-mouth construction; transit-mixed concrete for congested areas; separate trunk line transmission conduit systems where feasible; driven service pipes for customer connections; manholes should not be less than 6 ft. in height; street loading and roof strength precautions; shapes to conform to requirements; precast service boxes; transformer vaults under sidewalk; roof construction; covers and castings; ventilation.

Converters

FREQUENCY. Frequency Changers Also Have Stability Limits, T. G. LeClair and A. J. Krupy. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 558-561, 6 figs. Operating conditions indicated that synchronous tie between 25- and 60-cycle systems of Commonwealth Edison Co. might not remain stable under certain disturbances; tie consists only of two 40,000-kw. synchronous frequency changers; tests demonstrate that with both machines under full load loss of one under fault would cause loss of synchronism between systems, although sudden removal of one machine without fault did not.

Corrosion

UNDERGROUND STEEL. The Electrolytic Corrosion of Underground Metallic Structures by Stray Currents, C. M. Longfield. *Instn. Engrs. Australia—Jl.*, vol. 3, no. 8, Aug. 1931, pp. 283-285. Discussion of paper previously indexed from issue of May 1931.

Currents

ALTERNATING—TEXTBOOK. Alternating Currents, C. E. Magnusson. 4th edit., N. Y., McGraw-Hill Book Co., 1931, 685 pp., illus., diagrs., charts, tables, $5.00. Textbook for undergraduate students which discusses fundamental principles of subject and shows their application to industrial problems; changes in edition include rewriting and extension of chapter on instruments, new chapters on systems of units and symbols, on mercury-arc rectifiers and on hot-cathode rectifiers and oscillators, as well as many new diagrams and illustrations. Eng. Soc. Lib., N. Y.

Education

Study of Technical Institutes. *Jl. Eng. Education—Supp.*, vol. 22, no. 1, Sept. 1931, 39 pp., 7 figs. Summary report intended to present in small compass principal findings, conclusions and data of study for wide distribution; contents of bulletin divided into two parts; principal findings and conclusions, and summary of data.

UNITED STATES. Engineering Educational Standards, L. W. Wallace. *Agric. Eng.*, vol. 12, no. 9, Sept. 1931, pp. 343-345, 1 fig. Comments on Dr. W. E. Wickenden's report to Society for Promotion of Engineering Education; each institution should make thorough study of territory it serves and should major on problems peculiar to its area; need for greater standardization of research programs; engineering teachers should be systematically taught how to teach; engineering profession foundation needs to be broadened in direction of social and cultural graces. Before Am. Soc. Agric. Engrs.

Electric Drive

AUTOMOBILE PLANTS. Ford Substitutes A-C. Motors for 27,000 D-C. Units. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, pp. 452-455, 8 figs. Methods of changing 85,000 hp. in River Rouge plant to alternating from d-c. drives; benefits include conspicuous reduction to maintenance costs and large decrease of energy lost in plant distribution; studies of drive duties reveal opportunities for scaling down motor sizes.

CEMENT KILNS. Methods of Foolproof Control in Cement Works, S. Hopferwieser. *Brown Boveri Rev.*, vol. 18, no. 9, Sept. 1931, pp. 279-287, 18 figs. Complete diagram of connections for electric operation of rotary kiln plant; diagram of electric interlocking connections between drive of rotary kiln and corresponding cooling drum; diagram of connections for remote controlled three-phase double commutator motor of 130 kw.; 1,000-500 r.p.m. driving rotary kiln fan; electrical operation of Lepol rotary kiln plant.

GRINDING MACHINES. Motorization of Modern Grinders, J. W. Harper. *Iron Age*, vol. 128, no. 16, Oct. 15, 1931, pp. 988-991 and 1020-1021, 6 figs. Methods of mounting electric motors on different types of grinding machines; bench and floor-type machines; time ratings of grinder motors; chart showing relation of wheel speed to peripheral speed for grinding wheels of various sizes; high frequencies for high speeds.

Electric Power

ICE PLANTS. Unit Data on Distilled-Water Ice Plant, R. H. Parrish. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, p. 431. Twelve months' observed data on tons output and kilowatt-hour input on typical South Texas distilled water ice plant with capacity of 90 tons per 24 hr., using can system, may be of value to other similar sized plants as means of comparison.

INDUSTRIAL PLANTS. Industrial Electrification—III, R. H. Silmot. *Elecn.*, vol. 107, no. 2779, Sept. 4, 1931, pp. 304-306, 3 figs. Group drive *versus* individual drive; types and selection of motors; motor driven.

Load Control in Industrial Plants, R. R. Ruggles. *Power Plant Eng.*, vol. 35, no. 18, Sept. 15, 1931, pp. 935-937, 4 figs. Advantageous application of load regulation illustrated by hypothetical case of industrial plant with fluctuating load which purchases power from large central station but also equipped to generate certain portion of its total load requirements; typical wiring diagram of automatic load regulator working on prime mover.

Electric Equipment

EXHIBITIONS. Electrical Machinery and Instrument Design in the Nineteenth Century. *World Power*, vol. 16, no. 93, Sept. 1931, pp. 177-194, 10 figs. Chronological order of exhibits organized by British Electrical & Allied Manufacturers' Assn.; article divided into three parts: Part I dealing with history of development of electricity generator from Pixii's machine in 1831 up to d-c. machines constructed by Crompton, Brush, and between 1880 and 1890 and Ferranti alternator of 1882; Part II describes Instrument Section, and Part III gives brief description of power station model.

OPERATION. Practises That Improve the Operation of Electrical Equipment. *Power*, vol. 74, no. 8, Aug. 25, 1931, pp. 282-284, 4 figs. Modern operating practises that have been adopted to meet requirements for higher degree of reliability and demands for more exact knowledge of equipment performance.

Electrolytes

PUMPS. A Circulating Pump for Liquids, D. R. Barber. *Jl. Sci. Instruments*, vol. 8, no. 6, June 1931, pp. 183-188, 3 figs. Description of non-metal pump designed primarily for circulation of electrolytes; performance of apparatus is discussed from theoretical standpoint, and typical calibration curves obtained with experimental pump are given.

Elevators

ELECTRIC—SIGNAL SYSTEMS. Pre-Register Signal System Stops Elevators Automatically. *Power*, vol. 74, no. 11, Sept. 15, 1931, pp. 391-393, 5 figs. System in which signals to stop are registered in advance by buttons in car and from landings; at proper point in car's travel operator notified by signal to center car switch so that car will stop automatically at landing for which signal was given; equipment design and operation.

OFFICE BUILDINGS. Planning Elevators for Special Service, C. F. Scott. *Eng. News-Rec.*, vol. 107, no. 15, Oct. 8, 1931, pp. 569-571, 6 figs. Description of vertical transportation system of new McGraw-Hill building in New York; nine passenger cars are all 3,500 lb. capacity, in size 7 ft. 4 in. by 6 ft. 4 in., with openings 3 ft. 8 in. wide; high rise cars, running at 800 ft. per min., are equipped with automatic control; low-rise passenger cars, running at 600 ft. per min., are equipped for manual operation, with automatic leveling; smooth operation is obtained through perfected control and extra heavy guide rails; details of pliotron floor leveling mechanism.

Engineering Writing

Technical Writing, T. A. Rickard. 3rd edit., N. Y., John Wiley & Sons, 1931, 337 pp., $2.00. Interest in correct speech has become much more wide-spread since author's book first appeared in 1919, and many textbooks have appeared since that date; his work still remains, however, one of most readable and best guides to engineer who wishes to improve his power of expression; new edition, prepared for American Institute of Mining and Metallurgical Engineers, differs from second edition only in sundry small corrections. Eng. Soc. Lib., N. Y.

Engineers

UNITED STATES. Who's Who in Engineering, edited by W. S. Downs and M. M. Lewis. 3rd edit., 1931, N. Y., Lewis Historical

Publ. Co., 1536 pp., $10.00. Edition is restricted, in accordance with recommendations of advisory committee appointed by American Engineering Council, to living American engineers who have been practising or teaching engineering for at least 10 years; about 10,000 names are included, with authentic brief information regarding professional experience, publications; education, addresses, etc.; geographic index is given. Eng. Soc. Lib., N. Y.

Furnaces

ANNEALING. Annealing and Cleaning Strip Steel for Cold-Rolling. *Iron Age*, vol. 128, no. 16, Oct. 15, 1931, pp. 1000-1003, 4 figs. Layout and operation of electric furnaces at Cuyahoga works of American Steel & Wire Co.; 24 bell type furnaces of 90- to 100-kw. capacity each; operated on three-phase, 220-volt, 60-cycle current; artificial atmosphere; continuous cleaner with various new features in connection with take-up frame.

FOUNDRY. Electric Furnace Developments in Foundries, A. E. Greene. *West Machy. World*, vol. 22, no. 9, Sept. 1931, pp. 424-427, 5 figs. Change from crucible melting furnace to electric furnace; typical furnace installations for economical production of steel and cast iron.

GASES. Principles and Some Practical Applications of Electric Furnaces with Atmospheric Control, A. N. Otis. *Iron and Steel Engr.*, vol. 8, no. 8, Aug. 1931, pp. 352-359 and (discussion) 359, 14 figs. Apparatus for reforming hydrocarbon gases, such as butane, illuminating gas or natural gas into gas consisting largely of free hydrogen, for dissociating ammonia into hydrogen and nitrogen; cost of gases by various methods of procurement; dissociation pressure in atmospheres for iron oxide; hood furnaces for bright-annealing; elevator type furnaces; tunnel type counterflow furnace for heating and cooling in atmosphere of electrolene. Before Am. Iron and Steel Elec. Engrs.

Fuses

The Pressures Produced on Blowing Electric Fuse Links: The Effect of the Surrounding Atmosphere, G. Allsop and P. B. Smith. *Safety in Mines Research Board—Paper*, no. 67, 1931, 19 pp., 1 fig. Fuse links of tinned copper wire have been blown by currents ranging from minimum fusing current to medium overload current at 200 volts d-c. in closed rectangular vessel of 54.0 cu. in. capacity; vessel was thermally and electrically insulated evacuated and filled with gas at known pressure; gases used were: air, oxygen, nitrogen, hydrogen, chlorine, carbon dioxide and argon under atmospheric and other pressures; oscillograms and pressure records were taken during each experiment.

Generators

ALTERNATING CURRENT. Armature Reaction in Salient-Pole Alternators, W. H. Ingram. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 78, Sept. 1931, pp. 690-707, 11 figs. Theory of alternator as self-modulating dynamical system is outlined; fundamental in it is a family of field magnetomotive and electromotive force characteristics, of which rotor position coordinate is parameter.

WATERWHEEL. Umbrella-Type Generators Reduce Hydro Plant Costs, H. B. Crandall. *Power*, vol. 74, no. 10, Sept. 8, 1931, pp. 358-359, 4 figs. Construction of umbrella-type slow-speed vertical-shaft waterwheel generator and space requirements; comparison with machines of usual design; advantages and disadvantages of various designs of waterwheel generators.

Heating

BUILDINGS. The Electrical Heating of Buildings, R. Grierson. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1045-1090 and (discussion) 1091-1116, 21 figs. Types of electric warming equipment; general details and considerations, *i. e.*, measurement of comfort, physiological, hygienic, architectural and decorative aspect; ventilation; high-temperature *vs.* low-temperature radiating surfaces; continuous *vs.* intermittent heating, etc.; information as actual installations, etc., and bibliography given in 11 appendixes.

RAILROAD BUILDINGS. Reading Installs Thermal-Storage Electric Heating System. *Ry. Elec. Engr*, vol. 22, no. 9, Sept. 1931, pp. 239-240, 2 figs. Unique heating plant used in power dispatcher's building on electrified territory at Philadelphia.

Hydroelectric

PUMPED STORAGE. Waeggital Pumped-Storage Hydro-Electric Scheme. *Engineering*, vol. 132, no. 3425, Sept. 4, 1931, pp. 292-294, 4 figs. Power scheme near Zurich has annual output of 110,000 kw-hr. generated in two stations mainly during winter months; dam closing gorge is of solid gravity type, 363 ft. high by 515 ft. long; pressure tunnel of circular cross-section and 12-ft. internal diam. is capable of carrying 1,160 cu. ft. of water per sec.; Rempen power station has four vertical-shaft Francis-type spiral turbines, each with output of 22,500 hp. at speed of 500 r.p.m.; Siebnen station contains four turbines of same type with outputs of 14,750 to 17,500 hp. at 500 r.p.m.

Insulation

BUILDINGS. Control of Heat, Light and Sound in Modern Buildings, E. C. Rack. *Heat., Piping and Air Conditioning*, vol. 3, no. 9, Sept. 1931, pp. 734-740, 6 figs. Use of insulation for controlling heat, light and sound in modern plants and buildings has developed rapidly within past few years; practical discussion of utilization of insulation of modern buildings; economical thickness of insulation; research and materials for future.

Insulating Materials

STRENGTH. System Insulation Strengths, S. A. Stigant. *Elec. Rev.*, vol. 109, no. 2808, Sept. 18, 1931, pp. 425-426, 5 figs. Introduction to study of coordination of insulation strengths of electrical transmission systems.

Insulators

SUPPORTS. Simpler Supports for Pin Type Insulators. *Elec. Times*, vol. 80, no. 2082, Sept. 17, 1931, p. 431, 2 figs. Eradication of inherent disabilities of existing forms of pole top equipment is aimed at in new tubular system described below.

Lamps

GLOW—VOLTAGE. Now Low Voltage for Tube Lighting, E. Clute. *Am. Arch.*, vol. 140, no. 2600, Oct. 1931, pp. 42, 64 and 66, 6 figs. Revolutionary improvements in production of light by glass tubes filled with rare gases have made it adaptable to architect's requirements as never before; most important of all is recent practical development of low voltage tubes; some of applications and possibilities illustrated.

INCANDESCENT—BURN-OUTS. Calculating Lamp Burn-Out, H. H. Webb. *Elec. World*, vol. 98, no. 12, Sept. 19, 1931, p. 505, 1 fig. Simple formula for calculating normal rate of burn-out of lamps.

ULTRA-VIOLET. The Problem of the Definition and Measurement of the Useful Radiation of Ultra-violet Lamps, C. H. Sharp and W. F. Little. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 7, Sept. 1931, pp. 727-737 and (discussion) 737-743, 2 figs. Most of methods for measuring on basis of erythemal effect are approximate in character and in generality of cases do not give sufficiently comparable results; need for coordination in this field of measurement is pointed out and for establishment of standards both in form of standard methods and physical standards of erythemal radiation; second part reviews most commonly employed physical methods of measurement.

Light and Lighting

Visual Efficiency in Quiet and Noisy Workplaces, M. Luckiesh. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, pp. 472-473. Results of experiment in which rate of performing exacting visual work was measured in quiet room and in room in which several 10-kw. motor-generator sets were operated.

ULTRA-VIOLET. Industrial Uses of Ultra-violet, E. E. Free and C. C. Clark. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 7, Sept. 1931, pp. 744-755. Summary of industrial applications of ultra-violet under five main headings, each of which is discussed in detail with respect to previous accomplishments and probable future use; need of some simple, reliable means of measuring ultra-violet is stressed and plea made for sources of ultra-violet radiation more intense and more nearly monochromatic than those now available.

STREET. The Street Lighting Requirements of Different Types of Street, J. F. Colquhoun and W. S. Stiles. *Surveyor*, vol. 80, no. 2068, Sept. 11, 1931, pp. 255-256. Requirements which must be considered in lighting different types of streets: revealing power, attractiveness by night, attractiveness by day; dependence of these requirements on brightness level, diversity characteristics of source, etc.; disability and discomfort glare; spectacular lighting. Before Int. Illum. Congress.

Loud Speakers

DESIGN. Dynamic Loudspeaker Design—II, J. E. Goeth. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 112-113 and 130, 3 figs. Actual computation for typical case is given; data calculated are compiled in table form.

Magnetism

Influence of Hydrostatic Pressure on the Critical Temperature of Magnetization for Iron and Other Materials, L. H. Adams and J. W. Green. *Terrestrial Magnetism and Atmospheric Electricity*, vol. 36, no. 3, Sept. 1931, pp. 161-169, 5 figs. Tests in order to determine whether or not temperature at which iron and other ferromagnetic substances pass from magnetic to non-magnetic state is affected by increase of pressure; specimens of materials investigated were made up as core of miniature transformer or induction-unit, and placed in electrically heated pressure-bomb; six-volt alternating-current was supplied.

Manometers

IONIZATION. A New Design of an Ionization Manometer, E. K. Jaycox and H. W. Weinhart. *Rev. Sci. Instruments*, vol. 2, no. 7, July 1931, pp. 401-411, 11 figs. Vacuum gage described has been developed for measuring pressure of residual gas in highly exhausted experimental tubes used in study of thermionic and photoelectric phenomena at pressures of order of 0.00000001 mm. mercury or lower.

Measurements

A Resistor for the Measurement of Large Direct Currents, E. H. Rayner. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1155-1159, 2 figs. Serious uncertainties in effective value of low resistances for measurement of large currents may be caused by variations of current distribution at their terminals; temperature-rise is also important cause of variation; application of principles for reduction of these errors has been basis of design of resistor of 20 microhms, which has been found satisfactory as reference standard for measurement of currents up to 25,000 amperes.

Metering

REMOTE. Remote Metering System Calibrated Quickly, U. Davis. *Elec. World*, vol. 98, no. 11, Sept. 12, 1931, p. 458, 1 fig. Impulse remote metering system instruments can be checked from load dispatcher's office of Commonwealth Edison Co.; diagram showing 25-cycle part of system.

Microphones

CALIBRATION. The Calibration of Microphones, H. F. Olson and S. Goldman. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 106-108 and 130, 8 figs. Methods for calibrating various types of microphones including Rayleigh disk, actuator method and thermophone method; comparative curves are given for different microphones.

Motors

BRAKING. Dynamic Braking *versus* Plugging as a Means of Accurate Stopping, P. McShane. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 516-517, 4 figs. When accurate stopping is essential function of motor aplication, shunt-wound motor, because of its characteristics, is generally used; two methods are used to bring motor to stop, dynamic braking and plugging; simple discussion of both methods, their applications and advantages.

INDUCTION—CIRCLE DIAGRAM. The Circle Diagram of the Polyphase Induction Motor, C. C. Hawkins. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 417, Sept. 1931, pp. 1149-1154, 3 figs. Values of radius and coordinates of center of circle diagram of polyphase induction motor are determined algebraically in form covering not only ordinarily accepted equivalent network, but also more accurate equivalent network in which iron losses for stator and rotor are represented separately.

STARTING. A Combined Motor Starting and Power Factor Correcting Panel. *Engineer*, vol. 152, no. 3948, Sept. 11, 1931, pp. 276-277, 1 fig. Electrical Construction Co. has introduced motor-starting panel, in which all necessary gear for starting, protecting and improving power factor of squirrel-cage machine is contained.

SYNCHRONOUS. Emergency Full-Voltage Starting of Synchronous Motors, O. C. Nelson. *Power*, vol. 24, no. 11, Sept. 15, 1931, p. 399. Automatic emergency full-voltage starting accomplished by balanced-frequency relay; practical discussion of operating features.

Fans Cool Totally Inclosed Synchronous Motors, C. C. Shutt. *Power*, vol. 74, no. 11, Sept. 15, 1931, pp. 396-397, 4 figs. Synchronous motors of 250-hp. rating have been built that are totally inclosed and cooled by external and internal fans for use in severe atmospheric conditions and to operate at 5,000-ft. altitude; motor design and construction.

SYNCHRONOUS—BRAKING. Synchronous Motors Stopped in Three Revolutions, A. S. Rufsvold. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 556-557, 2 figs. 400 hp. motor stopped from 450 r.p.m. to rest in 1.25 sec. by allowing armature current only half inrush value at starting; this meets emergency stop conditions, eliminates coasting time of heavy equipment and is applicable to bandsaws, rolls and intermittent operations.

Networks

INTERCONNECTED. The Economic Value of Major System Interconnections, N. E. Funk. *Jl. Franklin Inst.*, vol. 212, no. 2, Aug. 1931, pp. 171-208, 24 figs. Table of power input, loss and delivery of 20 sections, 1,000-mile transmission line; why interconnections between power systems are desirable; details of 220-kv. interconnection of Pennsylvania Power & Light Co., Public Service Electric & Gas Co., and Philadelphia Electric Co.; details are given.

PROTECTION. Protecting A Medium-Voltage Network, J. S. Parsons. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 520-525, 5 figs. Proper operation of primary a-c. network depends upon satisfactory protective system; plan outlined makes possible adequate relaying, using only well-known and dependable equipment.

Oscillographs

CATHODE-RAY. A Method of Obtaining a Linear Time Axis for a Cathode Ray Oscillograph, A. L. Samuel. *Rev. Sci. Instruments*, vol. 2, no. 9, Sept. 1931, pp. 532-540, 5 figs. Usefulness of cathode-ray oscillograph tube of type of Western Electric no. 224-B is enhanced by any circuit that will provide linear time axis; one method used in Bell Telephone Laboratories employs hot-cathode three-element gas-filled tube in usual "sweep" circuit; this method possesses advantages in reproducibility, ease of control and synchronization; brief description of tube is given together with simple analysis of behavior of circuit. Bibliography.

Photoelectric

CALCULATING MACHINES. A Photoelectric Integraph, T. S. Gray. *Jl. Franklin Inst.*, vol. 212, no. 1, July 1931, pp. 77-102, 12 figs. Machine for purpose of facilitating mathematical solution of problems requiring evaluation of integral in which integrand involves variable parameter is described in this article; it involves use of optical system in which transmission of light is limited in definite manner by apertures having shape of area under curves representing mathematical functions; accuracy of machine itself is from 2 to 5 per cent.

Photoelectric Cells

Photocell Theory and Practise, V. K. Zworykin. *Jl. Franklin Inst.*, vol. 212, no. 1, July 1931, pp. 1-42, 33 figs. Methods of preparation of cell; application in motion pictures television. Simplicity Extends Light-Control Possibilities. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, pp. 21-22, 3 figs.; see also *Radio Industries*, vol. 6, no. 5, Sept. 1931, pp. 166-167, 3 figs. Burgess Radiovisor Bridge new light sensitive cell and simplified associated apparatus, introduced to engineers and experimenters.

COLORIMETRY. The Applicability of Photoelectric Cells to Colorimetry, H. E. Ives and E. F. Kingsbury. *Optical Soc. Am.—Jl.*, vol. 21, no. 9, Sept. 1931, pp. 541-563, 18 figs. Critical consideration of requirements for precision physical colorimeter, and estimation in light of experimental data on new types of photoelectric cells, as to what degree requirements for physical colorimetry may be met at present time; paper is very specially limited to problems of precision color measurement.

Photometers

DAYLIGHT. A Daylight Factor Integrator, H. C. H. Townend. *Jl. Sci. Instruments*, vol. 8, no. 6, June 1931, pp. 177-183, 5 figs. Instrument determines mechanically illumination at point on horizontal surface due to direct light from sky visible at that point; instrument is set up at point, and telescope incorporated in it is made to traverse boundary of visible sky; daylight factor is read off from small integrating wheel.

Photometry

A Method of Measuring the Integrated Light from Short Flashes of High Intensity, L. R. Koller. *Rev. Sci. Instruments*, vol. 2, no. 9, Sept. 1931, pp. 551-553, 1 fig. In course of some tests of flashing beacons for airports it was necessary to measure integrated light from flashes of high intensity but of very short duration; for this purpose circuit using photoelectric tube and thyratron was developed by means of which measurements could be made with great ease to within accuracy of about 10 per cent.

Power Industry

GOVERNMENT CONTROL. Governor Takes Firm Stand Against Government Ownership, A. C. Ritchie. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 540-542. Government ownership of power industry would make us political slaves of federal government; state regulation suitably strengthened where it is lacking will solve all problems better than any form of state ownership. Before Am. Bar Assn.

Power Plants

ELECTRIC DRIVE. Large and Small Motors in the Modern Industrial Steam Power Plant, E. A. Murray. *Eng. and Finance*, vol. 25, nos. 2 and 3, Aug. 1931, pp. 29-30 and 38, and Sept., pp. 48 and 57. Specific applications boiler feed pump; circulating pumps; hot-well pumps; forced and induced draft fans; stokers; pulverized coal feeders; pulverizer mills; clinker grinders.

NATURAL GAS. The World's Largest Industrial Consumer, R. M. Bauer. *West. Gas*, vol. 7, no. 5, May 1931, pp. 42-44 and 100, 6 figs. Description of Southern California Edison Co.'s Long Beach steam plant which burns natural gas in huge quantities to supply light and power needs of Southern California; article is non-technical in treatment, laying particular stress upon burner design and gas usage.

Radio

AIRPLANES. Radio on Dutch Air Lines Insures Safety, L. Bruchiss. *Radio Industries*, vol. 6, no. 5, Sept. 1931, pp. 168-169, 4 figs. As example of foreign radio in aircraft, air routes of K. L. M., Royal Dutch Air Lines are taken; began operations in 1920, and may be considered as hub of continental air traffic; since establishment of 10,000 mi. Holland-Dutch East India line, longest mail and passenger route in existence at present, K. L. M. radio equipped airplanes touch three continents; equipment is illustrated and described.

AMPLIFIERS. Tube Amplifier Equivalent Parallel Circuit, G. D. Robinson. *Electronics*, vol. 3, no. 3, Sept. 1931, p. 105, 1 fig. It is shown that parallel substitution for simple series circuit is merely simplification of general parallel equivalent circuit, in which internal plate resistance, load, and grid-to-plate reactance are all treated as being in parallel.

CONTROLS. An Analysis of the Series Type Mixing Control, L. B. Halliman, Jr. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, pp. 17-18, and 35, 8 figs. Discussion of various control systems and faders for use in radio broadcasting, talking motion picture and phonograph recording work, when using more than one microphone to obtain more natural and higher quality of reproduction or to have level from each microphone under absolute control and to have each control independent of other.

OSCILLATORS. Quartz Oscillator Wave Constants, E. G. Watts. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, pp. 23-26, 2 figs. Attempt to coordinate results of prominent investigators in field, presenting in summarized form data on constants of longitudinally and transversely vibrating modes, in so far as it is accurately known.

RECEIVING APPARATUS—AUTOMATIC CONTROL. Use of Vacuum Tube Operated Relay to Control Blasting in Radio Receivers, B. Ephraim. *Radio Eng.*, vol. 11, no. 9, Sept. 1931, p. 27, 2 figs. Diagram and analysis of simple relay control system in audio circuit.

RECTIFIERS. The Design of Power Rectifier Circuits, M. McDonald. *Wireless Engr.*, vol. 8, no. 97, Oct. 1931, pp. 522-531, 8 figs. Methods of calculating effect of resistance in circuit and also effect of variation in size of tank condenser; practical examples are given.

WAVES. The Expanding Short-Wave Spectrum. *Electronics*, vol. 3, no. 3, Sept. 1931, p. 91. Compilation of known data on present and future radio channels on waves from 30,000 to 7½ cm. is given on chart.

Railroads

ELECTRIFICATION. Railway Electrification—An Alternative Proposal. *Ry. Gaz.*, vol. 55, no. 10, Sept. 4, 1931, p. 298. Finance of main-line electrification; economical alternative; scope for reduced rates; advantages of oil-electric traction.

SIGNALS—INTERLOCKING. Electric Interlocking Installed in Birmingham, Ala., L. R. Stahl. *Ry. Signaling*, vol. 24, no. 9, Sept. 1931, pp. 309-311, 7 figs. Design, construction, and operating details of 47-lever plant at crossing of three roads; simplified track and signal plan of Birmingham plant.

SUBSTATIONS. Mobile Railway Substations. *Elec. Rev.*, vol. 109, no. 2808, Sept. 18, 1931, p. 427, 3 figs. Truck-mounted mercury-vapor rectifying outfits for Italian state railways for three-phase 16 2/3-cycle system direct current at 3,000-v. contact-wire pressure for Benevento-Foggia and other lines.

TRAIN CONTROL, AUTOMATIC. Automatic Train Control on the Southern Railway. *Engineer*, vol. 152, no. 3950, Sept. 25, 1931, pp. 332-333, 8 figs. In Strowger-Hudd system permanent magnets and electromagnets are used to operate receivers carried by locomotive, which cause whistle to be blown and continuous brake to be applied as required; receivers are actuated by inductors, of which there are usually three.

Railroad Crossings

SIGNALS AND SIGNALING. Crossing Protection Signals on the Milwaukee Road. *Ry. Signaling*, vol. 24, no. 9, Sept. 1931, pp. 316-318, 9 figs. Older type of protection replaced by flashing-light type with rotating stop disk; operating conditions; plan showing location of signals in Oconomowoc; control of signals.

Rectifiers

D-C. Conversion Equipment, A. M. Garrett. *Nat. Elec. Light Assn.—Bul.*, vol. 18, no. 9, Sept. 1931, pp. 595-598, 4 figs. Report of electric machinery subcommittee of Electrical Apparatus Committee; enclosed converters; method of determining adequacy of soldered joints; new developments in conversion equipment; total number and capacity of rectifier sets installed in United States and Canada; telephone interference; high speed switching for rectifier.

Relays

Electrical *versus* Mechanical Devices Used in Control and Regulation Engineering, J. F. Shadgen. *Iron and Steel Engr.*, vol. [illegible], no. 9, Sept. 1931, pp. 378-382, 12 figs. Corrective devices used in art of regulation; regulating valves; regulating dampers; rheostats; solenoids; brakes and clutches; characteristics of fluid amplifying devices; characteristics of electric amplifying devices. Before Am. Iron and Steel Elec. Engrs.

Rolling Mills

ELECTRIC EQUIPMENT. Electrical Equipment of the Slabbing and Hot Strip Mills at the Wheeling Steel Corporation's Steubenville Plant, J. Farrington and H. A. Winne; *Iron and Steel Engrs.*, vol. 8, no. 7, July 1931, pp. 324-336, 16 figs. Outstanding mill installations of recent years are 45 in. reversing Universal slabbing mill and continuous hot strip mill at Steubenville, Ohio, plant of Wheeling Steel Corp.; complete electrical installation, starting with incoming 66,000-volt power lines, carrying through Ohio Power Co.'s Fort Steuben substation, Wheeling Steel Corp., outdoor substation on to 60 in. mill motor room and main auxiliary drives.

ELECTRIC DRIVE. Electric Power is Regenerated by New Roll Train Drag, A. J. Whitcomb. *Steel*, vol. 89, no. 16, Oct. 12. 1931, pp. 31-33, 5 figs. Installation combining successful regeneration of electric power with production of dragging torque which prevents back lash in sheet mill in Detroit districts; power regenerated is 540,000 kw-hr. and represents saving of $5,400 per year.

Substations

AUTOMATIC. Electricity in Limestone Mining, F. P. Brightman. *Eng. and Min. Jl.*, vol. 132, no. 5, Sept. 14, 1931, pp. 205-206, 4 figs. Details of equipment and operation at double-unit, completely automatic substation installed at Pittsburgh Limestone Co.'s Buffalo Creek mine, near Worthington, Pa., to supply direct current to mine haulage system and for general use in mining operations; synchronous motor-generator sets were selected on account of greater flexibility in control of d-c. voltage and independence of fluctuations of d-c. system voltage which affect d-c. voltage when converters are used.

DESIGN. What a Well-Built Substation May Be. *Elec. World*, vol. 98, no. 14, Oct. 3, 1931, p. 612. Zanesville (Ohio) substation of Ohio Power Co., subsidiary of American Gas & Electric Co. is representative of best and most recent of today's electrical engineering practises, and includes in its design not only features of economy, reliability, safety and ease of operation but also attractive appearance.

Switchboards

Features of Modern Switchboards, E. G. Bern. *Power Plant Eng.*, vol. 35, no. 17, Sept. 1, 1931, pp. 897-899, 4 figs. Evolution has almost extinguished resemblance between earliest and latest switchboards; unit principle of design.

Switches

Elimination of the Disconnecting Switch Hazard, J. Auchincloss. *Power Plant Eng.*, vol. 35, no. 18, Sept. 15, 1931, p. 938, 2 figs. Methods illustrating impossibility of opening disconnecting switch until oil circuit breaker has first been opened; protection afforded by magnetic lock on mechanism of disconnecting switch which is controlled by auxiliary switch on mechanism of circuit breaker.

The Minatro—A New Idea in Control Switch Design, A. J. A. Peterson. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 508-510, 6 figs. Control switch requiring only 5 sq. in. of switchboard panel space, using toggle switches for quick make and break contacts, handling 125 volts directly and that can be mounted or dismounted as unit; neat appearance; it is result of deliberate attempt to design switch for specific purpose without regard for precedent or convention.

Telephone

CIRCUITS. Four-Wire Telephone Circuits, G. C. Crawford. *Bell Laboratories Rec.*, vol. 10, no. 1, Sept. 1931, pp. 6-12, 8 figs. Advantages and characteristics of four-wire circuits; details of 44 A-1 repeaters for use in 4-wire circuits; wiring diagram of repeater.

Television

APPARATUS—OPERATION. The Practical Operation of a Complete Television System, A. B. DuMont. *Radio Eng.*, vol. 11, no. 7, July 1931, pp. 33-36, 8 figs. Technical description of Jenkins system of television now in operation.

Transformers

FOUR-WINDING. Four-Winding Transformers. *Engineer*, vol. 152, no. 3948, Sept. 11, 1931, pp. 304-305, 4 figs. Three-phase, 50-cycle transformers with four windings built by Oerlikon Co. for Ryburg-Schwoerstadt Power Supply Co., Rheinfelden, Switzerland; capacity of each of windings is 32,500 kva. while continuous overload capacity is 35,000 kva.

INSTRUMENT. A Through Type Current Transformer and Amplifier for Measuring Alternating Currents of a Few Milliamperes, W. B. Kouwenhoven. *Rev. Sci. Instruments*, vol. 2, no. 9, Sept. 1931, pp. 541-548, 2 figs. Transformers and vacuum-tube amplifiers constructed for experimental study of effects of electric shock for measurement of current actually passing through vital organs; wiring diagram and characteristics of instrument.

PARALLEL OPERATION. Balance Coil or Reactor for Paralleling Transformers, E. C. Wentz. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 526-529, 8 figs. If transformers to be paralleled are different in turns ratio, balance coil is indispensable; balance coil must also be used when secondaries of two transformers are to be paralleled, and primaries are supplied from different sources; reactors, though more limited in application, are more easily installed and have advantage of simplicity.

SPARE WINDING. Grounding Transformer Bank Supplies Station Energy. *Elec. World*, vol. 98, no. 14, Oct. 3, 1931, pp. 612-613, 2 figs. To serve as spare source of energy for station service equipment, 2,000-kva., 33,000/13,200/2,300-volt grounding transformer bank has been provided with third winding for full-capacity output of 2,300 volts at Gilbert station of Associated Gas & Electric System at Holland, N. J.; wiring diagrams are given.

Transmission Lines

HIGH TENSION—ANALYSIS. Transmission Line Analysis Indicates Ruling Tendencies, E. B. Kurtz and J. A. Douglas. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, pp. 553-555, 10 figs. Graphical determination of relations between major design values of present-day electric power transmission lines was undertaken in belief that study of large number of lines would reveal general laws governing recent design practise; analysis is based on table on "Engineering Details of Transmission Lines in United States" published by *Electrical World* in 1929, giving engineering details of 877 high-voltage transmission lines.

HIGH TENSION—INSPECTION. Methods and Procedures for Inspection of Materials Used on Overhead Lines. *Nat. Elec. Light Assn.—Pub.*, no. 150, Aug. 1931, 38 pp., 1 fig. Procedures which if followed in inspecting conductors, poles, insulators and hardware, should result in obtaining satisfactory material; methods are intended to cover more important requirements in most practical way and to indicate common-sense interpretations of various specification requirements.

HIGH TENSION—RELAYS. Theory and Application of Relay Systems, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, pp. 535-538, 11 figs. Relay scheme for parallel line protection is outlined; various diagrams of connection are given.

Vacuum Tubes

Patents Relating to Electronic Devices in Industry. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 92-93, 5 figs. Three patents granted by United States Patent Office are described; Langmuir patent for connecting light-sensitive cell and vacuum tube; Logan method of using light-sensitive cell for regulating flow of gas in sulphuric acid manufacture; Logan patent by which light-sensitive cell is controlling shaft revolutions; Nakken patent for combination of light-sensitive surface and triode.

ELECTROCHEMISTRY. The Electron Goes to Work in Industry, J. A. Lee. *Electrochem. Soc.—Trans.*, vol. 59, 1931, pp. 229-236, 1 fig. In electrochemical industries vacuum tube has already been adapted for several purposes and it has been suggested for many others where increased accuracy of measurements and production efficiency are important; outline of various uses for tubes and photoelectric cells.

LABORATORY USES. Electronic Tubes in the Laboratory. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 114-115, 4 figs. Symposium consisting of four short articles; Life Test for Condensers, H. W. Houck; Circuits for Light Sensitive Cells; Piezoelectric Measuring Devices, J. Lluge, H. E. Linckh, R. A. Webster, S. L. Brown and S. Harris; Vacuum Tube Control for Electric Balances, F. S. Eastman.

MEASUREMENTS. A New Method of Measuring Vacuum Tube Characteristics, J. R. Barnhart. *Radio Eng.*, vol. 11, no. 7, July 1931, pp. 30-31, 4 figs. Method of determining dynamic mutual conductance, amplification factor and plate resistance was evolved mathematically from consideration of properties of self-biased tube; equipment used consists of source of filament current, source of plate current, galvanometer and suitable resistances.

PRESSURE INDICATORS. A Cylinder Pressure Indicator, L. R. Quarles. *Elec. Jl.*, vol. 28, no. 9, Sept. 1931, p. 519, 2 figs. Newly developed grid-glow tube device for testing internal-combustion engines makes possible continuous and visible indication of pressures in cylinders.

TELEVISION. A New Modulation Tube for Television, H. F. Dalpayrat. *Radio Eng.*, vol. 11, no. 7, July 1931, p. 37, 1 fig. New mercury vapor arc tube described has very large output of modulated light and shows great possibilities.

TESTING. Vacuum Tube Life Tests, J. N. Fuller and P. W. Charton. *Radio Eng.*, vol. 11, no. 7, July 1931, pp. 21-23, 2 figs. Test conducted to determine life span of product in question, consisting in subjecting it to continuous operation simulating actual usage conditions until it wears off and becomes unsatisfactory; for vacuum tube this means until one or more of its characteristics varies beyond specified limits.

VOLTMETERS. Vacuum Tube Voltmeter of High Sensitivity, H. J. Reich, G. S. Marvin and K. A. Stoll. *Electronics*, vol. 3, no. 3, Sept. 1931, pp. 109-111, 6 figs. For larger a-c. voltages or for d-c. voltages peak type of vacuum tube voltmeter can be used, but as ordinarily constructed, using three-element tube, sensitivity is rather poor; in order to find more suitable tube, survey was made of more recent types of tubes; results of this work have made possible development of sensitive portable instrument described.

Voltage Regulators

A Non-Contact Voltage Regulator *Elec. Rev.*, vol. 109, no. 2802, Aug. 7, 1931, p. 211, 4 figs. "No contact" equipment resembles hydraulic regulator used for water turbines; apparatus acts instantaneously and produces very high operating torque.

Watthour Meters

TESTING. Manual Switching Eliminated in Rotating Standard Testing. *Elec. World*, vol. 98, no. 13, Sept. 16, 1931, p. 542, 1 fig. Great sensitivity, combined with stable operation, is claimed for vacuum tube and switch device for timing rotating standards, developed in meter department of Puget Sound Power & Light Co., according to recent report of N.E.L.A. meter committee; nervous and muscular coordination of tester do not affect test when this equipment is used.

Welding

ARC—ATOMIC HYDROGEN. Hydrogen Welding Now Automatically Controllable, S. Martin, Jr. *Elec. World*, vol. 98, no. 13, Sept. 26, 1931, p. 561, 1 fig. Welding automatically with atomic hydrogen flame presents problem of maintaining definite size of flame in fixed plane between two slowly consuming tungsten electrodes; relation of fringe of flame and work is fixed mechanically; push-button control scheme for automatic hydrogen welding, is given.

ARC—ELECTRODES. Future Development of Electrodes, T. E. Jerabek. *Welding*, vol. 2, no. 9, Sept. 1931, pp. 623-625, 3 figs. Development of thicker coatings; automatic electrodes; physical composition of electrode; possibilities of electrodes ¾ in. in diam. operating at 1,000 amp.

CHROMIUM-NICKEL STEEL. How to Weld the Chromium-Nickel Steels, S. C. Alexander. *Welding*, vol. 2, no. 8, Aug. 1931, pp. 514-517, 7 figs. Practical applications illustrate welding technique; effect of temperature on physical properties of Nirosta KA2 or "18 and 8" chromium-nickel steel based on short time test.

HOUSES, STEEL FRAME. Arc Welded Steel Residences. *Constructor*, vol. 13, no. 9, Sept. 1931, pp. 26-27, 5 figs. Features of arc welded steel frame residences in Mamaroneck, N. Y., and at Shaker Heights, Cleveland, Ohio; method of using "Battledeck" steel flooring in connection with welded steel frame residence construction; method of fastening wood sleeper to battledeck floor construction.

NICKEL. British Practise in the Welding of Monel Metal and Pure Malleable Nickel, N. C. Marples. *Am. Welding Soc.—Jl.*, vol. 10, no. 3, Mar. 1931, pp. 14-17, 6 figs. Applicability of welding methods for monel metal and pure nickel sheet, with reference to thickness; oxygen control, fluxes, use of filter rod, automatic electric seam welding.

STEEL. Analysis of Steel for Welding, W. E. Stine. *Metal Progress*, vol. 20, no. 2, Aug. 1931, pp. 91-94, 5 figs. Investigations at Lincoln Research Laboratory to determine welding characteristics for metallic arc welding with bare or washed electrodes; metallic arc welding with special electrodes; carbon arc welding with completely shielded arc; Lincoln-Stine equilibrium curve showing relation between aluminum, silicon, and manganese in carbon steels to produce best welding characteristics.

STEEL STRUCTURES. Arc Welding Joints in Steel Structures, R. W. VanKirk. *West. Machy. World*, vol. 22, no. 9, Sept. 1931, pp. 405-406, 2 figs. Development of arc welded structural joints; permissible unit stresses; advantages of electric welding; inspection.

Welders

TRAINING. Training Welders for Industrial Work, C. D. Moore. *Welding Engr.*, vol. 16, no. 7, July 1931, pp. 37-38, 4 figs. Need of practical experience of welders in addition to school training; illustrations show various conditions under which welder is required to work.

Welds

STRESSES. Stress Relieving Welded Joints, R. E. Kinkead. *Welding Engr.*, vol. 16, no. 7, July 1931, pp. 25-28, 14 figs. Nature of residual strains in steel due to temperature change; series of tests of residual stresses in welds and methods of removal.

Wheatstone Bridges

ELECTROLYTES. A Bridge for the Measurement of the Conductance of Electrolytes, P. H. Dike. *Rev. Sci. Instruments*, vol. 2, no. 7, July 1931, pp. 379-395, 4 figs. Bridge which has been designed to give higher degree of accuracy than has previously been attainable in measurements of this type, and with greater convenience of manipulation and of interpretation of results.

Industrial Notes

Unemployment Relief Plan of I-T-E Circuit Breaker Company.—It is announced that two per cent of the gross sales of the I-T-E Circuit Breaker Company, Philadelphia, for the next five months will be donated to the relief organizations of the communities in which those sales originate. A special fund of $25,000 has been deposited with the Philadelphia Trust Company from which, within ten days after receipt of each order, a check will be drawn for the relief work. No order for less than fifty dollars will be included in this relief plan. These voluntary donations all over the country will be in addition to the Company's donations for local relief. It is the hope of the I-T-E Circuit Breaker Company that other members of the electrical industry as well as of other industries, may be led to adopt this plan or a modification of it for supplying the money needed to ameliorate the condition of the nation's unemployed.

New Frequency Monitor for Broadcasting Stations.—Announcement has been made that the General Radio Company, Cambridge, Mass., has just completed development of a new frequency monitoring equipment, which will enable broadcasting stations to check their frequencies to within ± 50 cycles per second of the assigned value in accordance with the requirements of General Order No. 116 of the Federal Radio Commission. A preliminary descriptive bulletin of this equipment is available.

A New Transmission Drive.—The American Engineering Company, Philadelphia, has developed a flexible electro-hydraulic transmission, delivering any speed from zero to the maximum of the unit. One end of the transmission is connected to an electric motor or prime mover rotating at a constant speed. From the other end intermediate, smooth speeds can be obtained from maximum to stop. Among the other advantages claimed for the new development are that the direction of rotation can be changed from one direction to the opposite direction almost instantly. Controls are available to make the transmission perform a series of operations automatically. The unit is extremely compact and no gears, pulleys, chains or belts are used in construction. It is shock-proof and self-lubricating; an across-the-line starter is all that is needed for control; has a high starting torque; and it is impossible to overload the device. At the present time 5 to 15 hp. units are being manufactured.

New Motor Starter.—The Electric Controller & Manufacturing Company, of Cleveland, Ohio, announces the "No. 1 Type ZEO Across-the-line Explosion-proof Starter," which has been officially approved by the Underwriters for Class 1, Group D hazardous locations. The enclosing case is strong and tight enough to prevent the transmission of any flame that may occur within the case to surrounding atmosphere, and the flanged joint between the upper and lower parts of the case is of sufficient length to cool any gases formed within before they can come in contact with the surrounding atmosphere. The contactor mechanism and overload relays are mounted on a slate base which is removable from the case. The main contacts and overload relay contacts are oil immersed and all working parts are kept well lubricated and protected from corrosion by capillary attraction of the oil. The maximum ratings of this starter are 5 hp., 110 volts, and 10 hp., 220, 440 and 550 volts.

Agency Appointments of Meter Devices Company.—J. G. Corrin, 140 North Sycamore Avenue, Los Angeles, has been appointed sales representative in California for the Meter Devices Company, Canton, Ohio. The Wagner Peterson Corporation, 535 Clifton Street, Portland, was recently appointed to represent the Meter Devices Company in the states of Oregon and Washington.

Kearney Corporation and Chance Company Merge.—It is announced that James R. Kearney Corporation, St. Louis, has combined with the Chance Company, Centralia, Mo., manufacturers of pole anchors. The combination makes it possible to supply every type of anchor for construction requirements from a single and centrally located manufacturer. The Kearney anchors include the 4-in-1 expansion anchor, steel rod screw anchor, pipe rod screw anchor and "No-Rench" screw anchor; the Chance anchors include the 2 and 4 way expansion anchor, pyramid "cone" anchor, never-creep plate anchor and steel screw anchor.

Trade Literature

Distribution Connectors.—Bulletin 38-T. Describes distribution connectors for copper and aluminum conductors, hot line clamps and insulated sticks. Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago.

Portable Instruments.—Bulletin 160, 12 pp. Describes Roller-Smith portable instruments—ammeters, voltmeters, volt-ammeters, single and polyphase wattmeters, frequency meters, power factor meters, transformers and multipliers. Roller-Smith Company, 12 Park Place, New York.

Motors.—Bulletin 210, 4 pp. Describes type "T" two-pole Reliance d-c. motors; semi-enclosed and fully-enclosed construction; pulley or sleeve bearings; in sizes up to 3 horsepower., 1,750 r.p.m. Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland.

High Tension Fuses.—Bulletin 39, 8 pp. Describes Pacific Electric distribution fuse cutouts, type EM fuse supports and type EM-1 fuse switches with type EX fuse holders. Pacific Electric Manufacturing Corporation, 5815 Third Street, San Francisco, Cal.

Circuit Breakers.—Bulletin GEA-959C, 12 pp. Describes General Electric type FKR-155 oil circuit breakers, 7,500 and 15,000 volts—400 to 3,000 amperes, triple pole—single throw. This type constitutes a complete line of indoor breakers for moderate and heavy duty service. General Electric Company, Schenectady, N. Y.

Motors.—Bulletin 20516, 2 pp. Describes new, single-phase Westinghouse motors, 2 to 7½ horsepower. Because of their excellent torque characteristics these motors have extensive applications on pumps, compressors, ventilating fans, blowers, farm machinery, and wherever high starting and high accelerating torques are necessary. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Asbestos Insulated Wires and Cables.—Bulletin 10-A, 30 pp. Describes Rockbestos insulated wires and cables, designed and built to withstand extremely high temperatures, oils and greases, the majority of acid fumes and vapors, etc. Specifications and descriptions are given for solid, coarse and flexible stranded cable with Rockbestos insulation from 600 to 7,500 volts; also switchboard wire, multi-conductor control cable, lead sheath control cable, locomotive cab cord, etc. Rockbestos Products Corporation, New Haven, Conn.

Circuit Testers.—Supplement, 2 pp. Describes Roller-Smith circuit testers. This low priced instrument can be used to ascertain if there is an electrical circuit existing between conductors applied to the terminals of the instrument and, secondly, it enables the user to read the resistance of the circuit under test. The HTD circuit tester is recommended by the maker for use in preference to magnetos and a-c. bell-ringing devices because of its accuracy of indications under all conditions and its lightness and compactness as well. Roller-Smith Company, 12 Park Place, New York.